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SALES hereby certify that annexed is a true copy of the Provisional specification
in connection with Application No. PQ1313 for a patent by
SILVERBROOK RESEARCH PTY LTD filed on 30 June 1999.

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SUPPORT AND SALES

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AUSTRALIA

Patents Act 1990

PROVISIONAL SPECIFICATION

Applicant(s):

SILVERBROOK RESEARCH PTY LTD

Invention Title:

A METHOD AND APPARATUS (NPAGE02)

The invention is described in the following statement:

A METHOD AND APPARATUS (NPAGE02)

Field of the Invention

The present invention relates to the field of information distribution and printing.

Background of the Invention

The background of the invention is detailed in the attached appendix A which also sets out a detailed description of the invention.

Summary of the Invention

It is an object of the present invention to provide an improved information distribution system.

In accordance with a first aspect of the present invention, there is provided an information distribution system for distributing customized information on print media, the system comprising a first series of data collection units for collecting customizable data; a network interconnecting the data collection units with a series of customization output printers; a series of customization output printers comprising: a user identification means to identify a user of the customization output printer; a printer activation means to activate the customization output printer; a pagewidth printer element for printing customized booklets; such that, upon activation of the user identification means and the printer activation means, the data collection units download a current customized booklet for the user and the printer element prints out the customized booklet.

The customization output printer can be arranged such that pages of the booklet are preferably fed through the printer from a top to bottom with the booklet being output at a bottom of the printer. The customization output printers can include a hopper located in the bottom thereof and the booklet can be gravity dropped into the hopper. The customization output printer further preferably can include a binding means for binding the pages of the booklet together. The binding means can comprise a fluid ejection device ejecting a glue onto a predetermined portion of substantially each page of the booklet. The binding means further can comprise compression means for compressing each page of the booklet together.

The user identification means can comprise a fingerprint scanner. The pagewidth printer can comprise an elongated wall mounted unit. The data collection units utilize multicasting facilities in downloading data to the customization output printers which select stories from the data collection units depending upon user interest. The customization output printers utilize public key cryptography for access control with the data collection units.

In accordance with a further aspect of the present invention, there is provided an information distribution system for distributing customized information on print media, the system comprising a first series of data collection units for collecting customizable data; a network interconnecting the data collection units with a series of customization output printers; a series of customization output printers comprising: a user identification means to identify a user of the customization output printer; a printer activation means to activate the customization output printer; a pagewidth printer element for printing

customized booklets; booklet collation means for collating the booklet; a print roll unit for storing rolls of print media for utilization for printing by the pagewidth printer element; such that, upon activation of the user identification means and the printer activation means, the data collection units download a current customized booklet for the user and the printer element prints out on the print roll unit pages of the

5 customized booklet which are formed into a booklet by the booklet collation means.

In accordance with a further aspect of the present invention, there is provided an interactive information distribution system comprising a series of interconnected data collection units for collecting information; an interconnected network; a series of printers for printing out information; a pen device including an image sensor for sensing an image area; wherein the image printed preferably can include a

10 series of visually distinctive areas containing identification information such that, upon placing the pen in the vicinity of a visually distinctive area, the pen is activated to sense and decode the identification information, the identification information is forwarded to the distribution computers which in turn creates a further customized page for forwarding to a printer unit for printing on demand of a user.

The identification information can be stored in conjunction with a user identification for

15 determining likely future news items of interest to the user. The information preferably can include advertising customized in accordance with a users selection of particular identifiers.

In accordance with a further aspect of the present invention, there is provided a news distribution system comprising a series of automated news collection units for collecting, collating and storing news stories; a distribution network for electronic distribution of news stories to a series of news

20 printers; a series of news printers interconnected to the news collection units via the distribution network for printing out a collection of news stories on demand on print media; the printing out including the . printing out of a series of detectable location markers on the print media; a handheld scanner unit adapted to scan the detectable location markers to determine a current scanning location on the print media, the handheld scanner being interconnected to the distribution network for transmission of the current

25 scanning locations to the automated news collection units; the automated news collection units utilizing the current scanning locations to determine customized future news stories to send to a user of the news printer.

The detectable location markers are preferably substantially invisible to the human eye. The detectable location markers can comprise a regularly spaced grid in conjunction with a unique

30 identifiable positional marker.

The news stories are preferably page formatted by the automated news collection units and downloaded in a compressed form over the distribution network. The news stories are preferably composited together into a page by the news printers.

The output printers are preferably double sided and included watermark data on images printed

35 out, the watermark data being detected by means of interference between a front and back surface of the print media.

In accordance with a further aspect of the present invention, there is provided a news distribution system comprising a series of automated news collection units for collecting, collating and storing news stories; a distribution network for electronic distribution of news stories to a series of news printers; a series of news printers interconnected to the news collection units via the distribution network

5 for printing out a collection of news stories on demand on print media; the printing out including the printing out of a series of detectable location markers on the print media; a handheld scanner unit adapted to scan the detectable location markers to determine a current scanning location on the print media, the handheld scanner being interconnected to the distribution network for transmission of the current scanning locations to the automated news collection units; the automated news collection units utilizing

10 the current scanning locations to determine customized future news stories to send to a user of the news printer. The handheld scanner unit can comprise a pen shaped unit.

The system can further comprise a charging unit for placing the pen shaped unit in to recharge the pen shaped unit. The charging unit can be cup shaped. The charging unit preferably can include a communications unit adapted to register pens placed in the charging unit with the printer.   The

15 handheld scanner unit preferably can include a series of accelerometers to determine a path taken by the handheld scanner unit. The handheld scanner unit preferably can include signature recognition means for recognizing a signature pattern executed by a user of the scanner unit. The pen shaped unit preferably can include an activation light which changes color in accordance with the operation being carried out by the pen shaped unit.

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Description Preferred in Other Embodiments

The preferred embodiment of the present invention is as set out in the attached appendix A which provides for a detailed description of the implementation of an information distribution and printing system denoted NETPAGE.

25   It would be appreciated by a person skilled in the art that numerous variations and/or modifications may be made to the present invention as shown in the specific embodiments in the attached documentation without departing from the spirit or scope of the invention as broadly described in the attached appendices. The present embodiments are, therefore, to be considered in all respects to be illustrative and not restrictive.

We Claim:

1.   An information distribution system for distributing customized information on print media, said system comprising:

a first series of data collection units for collecting customizable data;

a network interconnecting said data collection units with a series of customization output printers;

a series of customization output printers comprising:

a user identification means to identify a user of said customization output printer;

a printer activation means to activate said customization output printer;

a pagewidth printer element for printing customized booklets;

such that, upon activation of said user identification means and said printer activation means, said data collection units download a current customized booklet for said user and said printer element prints out said customized booklet.

2.   A system as claimed in claim 1 wherein said customization output printer is arranged such that pages of said booklet are fed through said printer from a top to bottom with the booklet being output at a bottom of said printer.

3.   A system as claimed in claim 2 wherein said customization output printers include a hopper located in the bottom thereof and said booklet is gravity dropped into said hopper.

4.   A system as claimed in claim 1 wherein said customization output printer further includes a binding means for binding the pages of said booklet together.

5.   A system as claimed in claim 4 wherein said binding means comprises a fluid ejection device ejecting a glue onto a predetermined portion of substantially each page of said booklet.

6.   A system as claimed in claim 5 wherein said binding means further comprises compression means for compressing each page of said booklet together.

7.   A system as claimed in claim 1 wherein said user identification means comprises a fingerprint scanner.

8.   A system as claimed in claim 1 wherein said pagewidth printer comprises an elongated wall mounted unit.

9.   A system as claimed in any previous claim wherein said data collection units utilize multicasting facilities in downloading data to said customization output printers which select stories from said data collection units depending upon user interest.

10.   A system as claimed in claim 1 wherein said customization output printers utilize public key cryptography for access control with said data collection units.

11.   An information distribution system for distributing customized information on print media, said system comprising:

a first series of data collection units for collecting customizable data;

a network interconnecting said data collection units with a series of customization

output printers;

a series of customization output printers comprising:

a user identification means to identify a user of said customization output printer;

a printer activation means to activate said customization output printer;

5   a pagewidth printer element for printing customized booklets;

booklet collation means for collating said booklet;

a print roll unit for storing rolls of print media for utilization for printing by said pagewidth printer element;

such that, upon activation of said user identification means and said printer activation

10   means, said data collection units download a current customized booklet for said user and said printer element prints out on said print roll unit pages of said customized booklet which are formed into a booklet by said booklet collation means.

12.   An interactive information distribution system comprising:

a series of interconnected data collection units for collecting information;

15   an interconnected network;

a series of printers for printing out information;

a pen device including an image sensor for sensing an image area;

wherein the image printed includes a series of visually distinctive areas containing identification information such that, upon placing the pen in the vercinity of a visually distinctive area,

20   the pen is activated to sense and decode the identification information, the identification information is forwaded to said distribution computers which in turn creates a further customized page for forwarding to a printer unit for printing on demand of a user.

13.   A system as claimed in claim 12 wherein said identification information is stored in conjunction with a user identification for determining likely future news items of interest to said

25   user.

14.   A system as claimed in claim 13 wherein said information includes advertising customized in accordance with a users selection of particular identifiers.

15.   A news distribution system comprising:

a series of automated news collection units for collecting, collating and storing news

30   stories;

a distribution network for electronic distribution of news stories to a series of news printers;

a series of news printers interconnected to said news collection units via said distribution network for printing out a collection of news stories on demand on print media;

35   said printing out including the printing out of a series of detectable location markers on said print media;

a handheld scanner unit adapted to scan said detectable location markers to determine a

current scanning location on said print media, said handheld scanner being interconnected to said distribution network for transmission of said current scanning locations to said automated news collection units;

said automated news collection units utilizing said current scanning locations to determine customized future news stories to send to a user of said news printer.

16.   A system as claimed in claim 15 wherein said detectable location markers are substantially invisible to the human eye.

17.   A system as claimed in claim 15 or 16 wherein said detectable location markers comprise a regularly spaced grid in conjunction with a unique identifiable positional marker.

18.   A system as claimed in claim 15 wherein said news stories are page formatted by said automated news collection units and downloaded in a compressed form over said distribution network.

19.   A system as claimed in claim 15 wherein said news stories are composited together into a page by said news printers.

20.   A system as claimed in claim 15 wherein said output printers are double sided and included watermark data on images printed out, said watermark data being detected by means of interference between a front and back surface of the print media.

21.   A news distribution system comprising:

a series of automated news collection units for collecting, collating and storing news stories;

a distribution network for electronic distribution of news stories to a series of news printers;

a series of news printers interconnected to said news collection units via said distribution network for printing out a collection of news stories on demand on print media;

said printing out including the printing out of a series of detectable location markers on said print media;

a handheld scanner unit adapted to scan said detectable location markers to determine a current scanning location on said print media, said handheld scanner being interconnected to said distribution network for transmission of said current scanning locations to said automated news collection units;

said automated news collection units utilizing said current scanning locations to determine customized future news stories to send to a user of said news printer.

22.   A system as claimed in claim 21 wherein said handheld scanner unit comprises a pen shaped unit.

23.   A system as claimed in claim 22 further comprising:

a charging unit for placing said pen shaped unit in to recharge said pen shaped unit.

24.   A system as claimed in claim 23 wherein said charging unit is cup shaped.

25.   A system as claimed in claim wherein said charging unit includes a communications unit adapted to register pens placed in said charging unit with said printer.

26.   A system as claimed in claim 21 wherein said handheld scanner unit includes a series of accelerometers to determine a path taken by said handheld scanner unit.

27.   A system as claimed in claim 21 wherein said handheld scanner unit includes signature recognition means for recognizing a signature pattern executed by a user of said scanner unit.

28.   A system as claimed in claim 22 wherein said pen shaped unit includes an activation light which changes color in accordance with the operation being carried out by said pen shaped unit.

29.   A system as claimed in any previous claim wherein images are printed on different sides of print media so as to produce a watermark interference effect between the two layers.

29.   A network news distribution system substantially as hereinbefore described with reference to the attached appendices.

30.   A network news distribution system as claimed in any previous claim when utilizing an ink jet print head having a series of spaced apart thermal bend actuators for the ejection of ink.

ABSTRACT

An information distribution system for distributing customized information on print media, the system comprising a first series of data collection units for collecting customizable data; a network interconnecting the data collection units with a series of customization output printers; a series of customization output printers comprising: a user identification means to identify a user of the customization output printer; a printer activation means to activate the customization output printer; a pagewidth printer element for printing customized booklets; such that, upon activation of the user identification means and the printer activation means, the data collection units download a current customized booklet for the user and the printer element prints out the customized booklet.

Appendix A

OVERVIEW

1   Introduction

Netpages are pages of high-quality text, graphics and images printed on ordinary paper, but which work almost like interactive Web pages. Information encoded on each page in invisible ink is picked up by an optically-imaging pen and transmitted to the network. Active "links" and "buttons" on each page can be "pressed" with the pen to request information from the network or signal preferences to a server. Text written by hand on a Netpage is automatically recognized via the pen, allowing forms to be filled in. Signatures recorded on a Netpage are automatically verified, allowing e-commerce transactions to be securely authorized.

The pen, shown on the right, works in conjunction with a Netpage Printer, an Internet-connected printing appliance for home, office or mobile use. The pen is wireless and communicates with the Netpage Printer using an encrypted radio frequency signal.
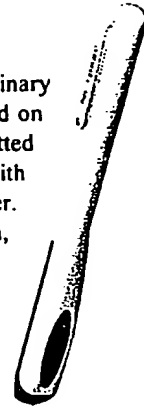
The Netpage Printer delivers, periodically or on demand, personalized newspapers, magazines, catalogs, brochures and other publications, all printed at high quality as interactive Netpages. Unlike a personal computer, the Netpage Printer, shown on the right, is an appliance typically wall-mounted in the kitchen or near the breakfast table, i.e. the place where the morning news is first consumed, and the household's point of departure for the day. It also comes in tabletop, desktop, portable and miniature versions.

Netpages printed at their point of consumption combine the ease-of-use of paper with the timeliness and interactivity of an interactive medium.

Netpages are crucially enabled by Memjet printing technology [4], which makes high-speed magazine-quality printing affordable to consumers. A Netpage publication has the physical characteristics of a traditional news magazine, i.e. a set of letter-size glossy pages printed in full color on both sides, bound together for easy navigation and comfortable handling. The Netpage Printer prints 60 to 90 full-color Netpages per minute.

The Netpage Printer exploits the growing availability of broadband Internet access. Cable service is available to 95% of households in the United States [75], and cable modem service offering broadband Internet access is already available to 20% of these [13]. The Netpage Printer also operates with slower connections, but with longer delivery times and lower image quality.

Netpage Publication Servers on the Internet deliver print-quality publications to Netpage Printers. Periodical publications are delivered automatically to subscribing Netpage Printers via pointcasting and multicasting Internet protocols. Personalized publications are filtered and formatted according to individual user profiles.

A Netpage Printer supports any number of pens, and a pen can work with any number of Netpage Printers. Each Netpage Pen has a unique identifier. A household may have a collection of colored Netpage Pens, one assigned to each member of the family. This allows each user to maintain a distinct profile with respect to a Netpage Publication Server. A Netpage Pen can also be registered with a Netpage Registration Server and linked to one or more payment card accounts. This allows e-commerce payments to be securely authorized using the Netpage Pen. The Netpage Registration Server compares the signature cap-

tured by the Netpage Pen with a previously registered signature, allowing it to authenticate the user's identity to the e-commerce system. Other biometrics can also be used to verify identity. A version of the Netpage Pen includes fingerprint scanning, verified in a similar way by the Netpage Registration Server.

Although a Netpage Printer delivers periodicals such as the morning newspaper without user intervention, it never delivers unsolicited junk mail. It only delivers periodicals from subscribed or otherwise authorized sources. The Netpage Printer is unlike a fax machine or e-mail account which is visible to any junk mailer who knows the telephone number or email address.

1.1   PUBLISHING TO NETPAGE PRINTERS

There are a number of advantages to publishing to Netpage Printers. The magazine quality of Netpage Printer output makes it a more attractive publishing and advertising medium than both traditional newsprint and computer screens.

The cost of paper and ink consumption is transferred to the user. Subscription fees can be eliminated entirely in lieu of the user taking on this extra cost, and the user thus perceives a better-value product. The erratic price of newsprint is removed from publishers' profit equations, resulting in more stable margins. A new market for paper and ink consumables, with its own margins, is created.

The cost of consumables can be selectively subsidized, for example when non-editorial publications such as product brochures and account statements are printed.

Capital and maintenance expenditure on printing plant is effectively transferred to the user, although the perceived expense is small because Netpage Printers are sold at close to cost or given away to encourage adoption, subsidized by future advertising profits. Maintenance can also be subsidized or its cost included in a longer term service agreement.

Costly physical distribution is replaced by electronic distribution via a preexisting and widely subscribed network - the Internet.

Both the editorial and advertising content of publications delivered via the Netpage Network can be customized for each user. Editorial content can be personalized according to the user's profile. Advertising can be localized to the user's locality and optionally targeted to the user's demographic.

A personalized publication can be a small fraction of the size of its traditionally-delivered counterpart, yet contain the same amount of information relevant to the user, and in a more accessible form. The user appreciates the more efficient and digestible publication.

Localized advertising can be targeted to more specific localities and their associated demographics, and this allows advertising space to be exploited more efficiently, i.e. with less waste. Advertisers are constantly pressing traditional publishers for greater localization, something which they have great difficulty delivering cost-effectively.

By revealing personal information such as age, gender, marital status, income, profession, education, etc., the user can allow the advertising to be more carefully targeted. In return they can receive greater subsidies and discounted product offers. As advertising becomes more targeted, it becomes less of a nuisance and more of a service in itself.

Although the publication's per-page circulation figures fall drastically, the publication's actual per-section readership is preserved, and the correspondingly higher advertising rates for personalized delivery can exactly compensate for this.

Advertising delivered via the Netpage Network has the dual benefits of print and online delivery. Print supports the impact of large-format ads. Online delivery supports customization, linking, and measurability, and consequently online charging models.

Consider a full-page advertisement for a new car model in a news magazine delivered via the Netpage Network. The advertising campaign can be national or even international. The ad only appears if compatible with the user's demographic, either implied by their ZIP code or more explicitly by their personal details. Anyone who requests a product brochure via the on-ad button receives one immediately via their Netpage Printer, customized with a list of local dealers. If they press a particular dealer's "contact me" button in the brochure, the dealer receives a message via the system and contacts the user by telephone.

The publisher profits in the normal way by selling the advertising space, but can also profit by receiving a fee on the "click-through" to the brochure, and a commission on any product sale which eventuates.

The Netpage Network promises to be the most effective advertising medium ever conceived. It combines the editorial and print quality of traditional publications with arbitrarily finely targeted advertising, and provides a direct link between advertising, product information, and purchasing. Added revenue from click-through fees and e-commerce commissions may even allow users' costs - printer, ink, paper, and Internet access - to be fully subsidized.

2   The Demise of Paper

Online publication has many advantages over traditional paper-based publication. From the consumer's point of view, information is available on demand, information can be navigated via hypertext links, information can be searched, and information can be automatically personalized.

From the publisher's point of view, the costs of printing and physical distribution are eliminated, and the publication becomes more attractive to the advertisers who pay for it because it can be targeted to specific demographics and linked to product sites.

Online publication also has a few disadvantages. Computer screens are inferior to paper. At the same quality as a magazine page, an SVGA computer screen displays only about a fifth as much information[1]. Both CRTs and LCDs have brightness and contrast problems, particularly when ambient light is strong. Ink on paper, being reflective rather than emissive, is both bright and sharp in ambient light.

Faced with reading more than the most trivial amounts of text on a screen, most people prefer to print it before reading it. Increasingly, online publishers are recognizing this and providing information in formats suitable for printing. At one extreme this means providing text-only versions of documents so they print efficiently, i.e. without imposing a screen format on the printed page; at the other extreme it means providing formatted versions of documents - e.g. in Adobe's Portable Document Format (PDF) - so they print at high quality.

Editorial content is often compromised to fit the online medium and the habits of the people who frequent it, who tend to browse rather than read. Although powerful new advertising models become possible, it becomes more difficult to deliver effective advertisements.

To truly enable online publication, many people envisage a universal information appliance - a lightweight portable "tablet" with a page-size touch-sensitive color display and a high-bandwidth wireless connection to the Internet. First proposed by Xerox PARC's Alan Kay in the mid 1970s in the form of the "Dynabook", and partially realized in recent paperback-sized electronic books, even Bill Gates is now confidently predicting that such a device will soon augur the death of paper publications [30].

To achieve low power consumption, low weight, and paper-like display quality, a bistable reflective display technology is required. Several candidates are now emerging from the labs, including Kent Display's cholesteric LCD technology (chLCD) [48], Xerox' "Gyricon" rotating ball technology [35], and E Ink's electrophoretic technology [26,62]. ChLCD is arguably closest to practical deployment [25].

Next-generation cellular phone networks promise 2Mbps packet switching [27], comparable to the broadband access people are getting used to in cable networks [59]. Satellite networks, while offering or promising still higher speeds [39,65,81], require receivers difficult to deploy in mobile devices.

Beyond the vision of the basic tablet, E Ink imagines its digital ink "printed" onto a number of flexible pages bound into a book, preserving the physical navigability of a paper-based publication, and approaching its low cost, but allowing the pages to be rewrit-

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1. Assuming a magazine page has an equivalent digital resolution of 200 continuous-tone pixels per inch.

ten electronically in place. They optimistically predict newspapers delivered in this way within five years [21], despite fundamental problems yet to be overcome [25].

The advantages of a tablet are many. Unlike a desktop or notebook computer, a tablet may actually provide a pleasant reading experience. Unlike a paper publication, a tablet provides intelligent access to an unlimited amount of information; its weight is not dictated by the amount of information it carries. More than just an information appliance, it can also act as a multi-purpose multimedia communications device and interactive entertainment device.

A tablet has disadvantages too. It uses batteries which run down and have to be recharged. It may break when dropped or malfunction when exposed to hot coffee. It's not quite cheap enough to be disposable - so there's still a problem if it's misplaced or stolen. It has a "user interface" which has to be learned. The leading candidate display technology - chLCD - is still less than half as reflective (i.e. "bright") as paper.

The drawbacks of traditional paper-based publications have little to do with paper itself, and much to do with how the information gets onto the printed page. The economics of centralized printing and distribution prevent the kind of information selection, personalization and navigation people have come to expect from interactive electronic media such as the Internet. The inefficiency of printing and distributing a hundred-page newspaper to a customer who may read only a few pages is widely decried.

Given a technology such as Memjet, it becomes economic to print high-quality publications at their point of consumption rather than at their point of production. The Netpage Printer leverages Memjet to deliver personalized publications to the home, gaining many of the advantages of online publication, while retaining the ease-of-use of high-quality printed ink on paper.

Netpages and the Netpage Printer address the key problems of online publication, without relying on the development and consumer acceptance of a new reading device.

3   News and Advertising Trends

3.1   NEWSPAPERS

People obtain news from a variety of sources - network and cable television, radio, daily newspapers, and weekly newsmagazines. In the United States, although the various news media are healthy and profitable, per capita news consumption is somewhat in decline as a new generation of young adults have less time to read and favor television entertainment over news [22]. Yet six out of ten adult Americans read a newspaper every day [68].

The United States has about 1500 daily newspapers with a total circulation of 57 million. Just the top ten "national" dailies (Wall Street Journal, USA Today, New York Times, Los Angeles Times, Washington Post, etc.) account for a circulation of 10 million. The major weekly newsmagazines (Time, Newsweek, U.S. News) have a similar (weekly) circulation of about 10 million.

In 1997, newspaper companies' revenue exceeded $24 billion, a five-year high, and margins nudged 20% [51], due both to increased spending on advertising and to reduced prices of newsprint.

Television and radio, by their nature, excel at delivering breaking news. Newspapers and newsmagazines, on the other hand, deliver the depth and analysis behind the headlines. Broadcast news in isolation does a poor job of informing the public. The more local the news is, the poorer the broadcast coverage, and the greater the public's dependence on newspapers.

Newspaper content and packaging has evolved considerably since the 1970s. News is somewhat softer, news stories are shorter and more well-written, there are more feature articles, and there is more editorial and reader opinion. Newspapers are more structured. Identifiable sections make them more accessible, and provide greater focus for advertisers. Much special-interest content has migrated from daily inclusion to weekly sections. These cover topics such as lifestyle, personal finance, entertainment, technology, etc. The proportion of graphics and pictures is greater. Color is widely used. Newspapers are easier to use and more entertaining than ever before, if at the expense of some "hard" news.

Daily newspapers are growing increasingly dependent on the various wire services. A newspaper may excel at local and regional news, but rely on the major wires (Associated Press and United Press International) for national and international news, the so-called "supplemental" wires (LA Times/Washington Post, NY Times, Scripps-Howard, Knight-Ridder Tribune, etc.) for specific strengths (and value-for-money), and the international wires (Reuters etc.) for international perspective. A growing number of newspapers operate more as news aggregators than news gatherers.

Advertising typically contributes more than 75% of newspaper and magazine revenue, while subscriptions contribute less than 25% [34,66,67]. National advertising makes up roughly 14% of advertising spending, retail advertising 46%, and classified advertising 40% [67].

Advertisers are pursuing increasingly specific targeting, favoring quality newspaper readership over raw circulation [29], and using more targeted media where possible. Magazines, for example, have more specific readerships than newspapers, free "shoppers" are

very localized by their nature, while direct mailers can target demographics based on individually-categorized ZIP codes, or databases of individuals.

Newspapers have responded with geographically zoned editions to support local advertising, and greater sectioning of their product. They have also expanded their page counts to provide more advertising scope, despite erratic newsprint prices in the 1990s [8].

Despite this, there is ongoing conflict between newspapers' mass distribution model, and advertisers' need for micro-targeting [33]. This conflict, coupled with advertisers' desire for higher-quality printing of color images, is motivating a shift from run-of-press (ROP) advertising to inserts [67]. The downside to inserts is that editorial context is lost.

3.2   ONLINE NEWS DELIVERY

Fearing the online migration of advertising, traditional news publishers from both broadcast and print have ventured into Internet-based news delivery, wanting to establish a presence at whatever cost before newcomers become entrenched. Most newspapers are still reporting losses from their online operations [67].

Online news delivery offers a number of advantages. Breaking news can be delivered as soon as it happens. News can be customized for individual readers according to their preferences and geographic locations. Readers can explore stories to arbitrary depth, follow links to related resources, and search archival material. Readers can participate in discussion groups and contribute to opinion polls. The news itself can incorporate audio and video clips, and can include live transmissions, converging with broadcast.

Online news delivery also has disadvantages. Computer screens are of limited size and quality compared with print. Few people enjoy reading a story of any length on a computer screen. Computers are not portable in the wide sense that a newspaper is. The news may be more timely, but the time and place in which it can be consumed are more constrained than with a newspaper.

Despite the power of hypertext, many online readers express a preference for a linear presentation, "where they [can] skim one section after another until the presentation [is] exhausted" [15]. Interestingly, a majority of traditional newspaper readers admit they scan every page in the main section of the newspaper [68], looking for items of interest without necessarily knowing what they're looking for, and achieving some kind of closure at the end. Online hypertext, by contrast, is both a limitless resource and a bottomless pit.

While traditional news publishers such as The New York Times can deploy full editorial content online [82], newcomers such as Yahoo typically only provide "raw" news items sourced from the wire services [63].

A recent survey indicates that 21% of the 74 million Internet users in the United States regularly read news online as an alternative to traditional print and broadcast sources, and 16% obtain a major proportion of their news online [69]. More broadly, between 37% and 64% of the Internet population reads news online at least once a week. The fluctuations in the figures are related to what may be happening in the news. Major or breaking news stories attract more users - 46% of Americans say they only follow national news stories when "something major is happening" [28].

With 41% of Americans online, the Internet population has become mainstream, and the weather has become the most popular news online. This is closely followed by technology

news, entertainment news, and local news. As one observer puts it, all of this "sound[s] like the 6 o'clock news" [69]. As a reflection of these habits, the online audience share of national newspapers has diminished from 23% in 1995 to 16% in 1998, while the online audience share of broadcast TV sites has grown.

3.3 ONLINE ADVERTISING

At its simplest, advertising alerts a motivated customer to the availability of a product, possibly at a competitive price. At a more sophisticated level, advertising seeks to influence future purchasing decisions by creating brand awareness. Ultimately, advertising seeks to create desire for a product even when actual need is absent.

Advertising prices are traditionally based on how many people see the advertisement, and their spending power in relation to the product. In practice, the more homogeneous the demographics of the audience, the easier it is to match to a product, and hence the higher the corresponding advertising cost per thousand (CPM). Broadcast media use ratings and timeslot demographics to set advertising rates. Print media use audited circulation figures and sectional readership demographics.

The simplest online advertising model is also based on how many people see the ad. Online this has the advantage of being based on solid numbers, since the number of "impressions" of a particular Web page can be counted exactly.

The specific advantage of an online ad, however, is that the ad itself can measurably capture a sales lead by acting as a link to a product site. The product site may simply provide more product information in the form of specifications, pricing, and ordering details. It may also support immediate online ordering, thus completing the link from ad to sale. Beyond providing simple ad exposure, it is this measurable linking of advertisement to sales lead or sale which is the strength of online advertising [73]. Cost per click (CLC) charging is gaining acceptance but is still controversial.

Beyond CLC, there exists the possibility of paying a commission to the ad host on any sale that actually eventuates [76]. Amazon.com is probably the best-known example of a company paying commissions to other sites in this way.

The broader advantage of online advertising is that advertising can be localized and targeted arbitrarily finely, in conjunction with the publication of online content such as news. This is the strategy pursued by online advertising agencies such as Click-Through [19], which acts as the middle-man between advertisers and online content publishers. They expect online advertising to represent more than 10 percent of all advertising revenue by 2001.

Since online ads are necessarily small-format, they communicate best with motivated customers already on the look-out for a particular product or service. Online ads are less suited to building brand awareness or creating buying desires, since the real substance of the advertisement - the product Web site - is a click away from the initial small-format ad. A small-format online ad can't provide the single-hit emotional impact of a large-format print ad, and conversely, the online world can't support the large-format ads that print can.

So-called interstitial ads, which appear full-screen when traversing from one page of information to the next, go some way to providing a medium for larger-format ads online [76]. User resistance, however, seems to be preventing their widespread use.

3.4   ONLINE CLASSIFIED ADVERTISING

Classified advertising is indisputably suited to online delivery. Unlike their traditional printed counterparts, online classifieds can be easily searched, and are not subject to space constraints. The online migration of classified advertising is considered a serious threat to newspapers' classified advertising profits [78], and some newspapers are building an online presence for this reason alone. Some observers predict as much as 50% of classified advertising revenue moving online within the next ten years [98].

Another problem faced by newspapers, who rely on classifieds for up to 40% of advertising spending, is that many newcomers are offering free online classified advertising as a way of building a venue for non-classified advertising.

4   News Personalization

From the reader's point of view, a personalized news publication can provide more information in fewer pages. The actual form this personalization takes, however, is not necessarily obvious.

The MIT Media Lab's News in the Future (NiF) project has been championing the concept of "The Daily Me" for almost two decades [60]. Nicholas Negroponte, one of the project's founders, envisages a highly personalized news publication which is no longer driven by "what other people think is news" [64]. By way of examples close to his own needs, it includes news about people and places about to be encountered, and puts "the most important [news] of all" - a summary of e-mail - on the front page [11]. Negroponte recognizes the need to vary the degree of personalization, advocating a higher "serendipity factor" on a lazy Sunday than on a working weekday.

The opposing view holds that the value of a news publication lies precisely in its *shared* nature. It reflects the common concerns and values of a community of readers, and establishes a baseline of expectations of what they are all supposed to know [89]. As a consequence, the publication also speaks with a consistent editorial voice and with consistent assumptions about the reader's level of background knowledge. Such a shared publication allows its readers to orient themselves in relation to their community.

NiF's Walter Bender answers the charge (in his own words) of "The Daily Me engendering a fragmented world populated by self-interested myopes", by stressing the possibilities of personalizing individual news items [9]. This can consist in varying the depth of an item, or supplementing it with background information, based on the reader's level of knowledge. It can involve interpreting information relative to the reader's background, such as (somewhat dubiously) making value judgements about the weather relative to the reader's normal home town weather. It can also be as simple as using metric rather than imperial units.

FishWrap [15,61], MIT's personalized campus newspaper and NiF's latest offering, goes further by creating a front page whose content represents an explicit community consensus. Each front page news item is prioritized according to the number of readers who put it forward for inclusion. The rest of the newspaper is still personalized according to each reader's profile, consisting of reader-defined sections containing topics of interest.

There are two implications of recognizing the shared nature of news. Firstly, some news is news to everybody in a community, no matter how personalized they claim they would like their news to be. This implies that the community must make decisions about news item priority, either directly (as in FishWrap) or indirectly via a proxy (i.e. an editor).

Secondly, a news item can only be properly understood in the context of the community for which it is intended. This implies that a news item must be branded with its source (assuming that the source implies the intended target). As an example, it is significant whether a news item regarding the proof of Fermat's last theorem is branded with New Scientist or The New York Times. To a professional mathematician, the latter implies, by its very existence, that the proof is of significance beyond the scientific community.

Of course, a news item must also be branded to allow its source to build and maintain its brand. The brand then allows the reader to infer the quality of the news item from the known quality of the source.

Most personalization of news uses *feature-based filtering*. This means that news item content is matched to topics and keywords in the reader's profile. News sources tag the items they produce with various information to allow them to be effectively filtered. This tagging may be brief or extensive, and may include such things as news item urgency, byline, news category, subject(s), keyword(s), date and time, and location [44]. The body text of a news item can also be scanned directly for keywords, but this may result in false matches if keywords are interpreted out of context. Items in the text such as personal names and locations can be tagged to reduce such ambiguity [44]. Similarly, dates, times, and monetary amounts can be tagged to allow localized presentation.

Feature-based filtering suffers from a number of problems. Filtering based on tags is only as good as the original tagging. The latest tagging standards are only just beginning to be adopted [12]. Filtering based on the text itself is constrained by the intelligence of the text parsing. If based simply on keyword matching, it can be both inaccurate, generating false matches because of word sense ambiguity, and imprecise, generating false mismatches because of a lack of inference.

Feature-based filtering is incapable of discerning more abstract attributes such as quality, style, and point-of-view (unless they're indicated by tags). And since it only matches items anticipated by the user's profile, it is a poor generator of serendipitous finds.

FishWrap's front page comes into existence based on a crude form of *collaborative filtering*. In its broader form, collaborative filtering involves sharing recommendations (or ratings) among *like-minded* people [74]. This means that one person's ratings influence another person if and only if the two share similar interests, i.e. they have similar rating histories. Collaborative filtering overcomes many of the problems of feature-based filtering, since ratings originate with people who have digested the items in question, rather than from automated analysis of the items. Collaborative filtering sidesteps the issue of *explaining* why a person might like a particular item.

Collaborative filtering has problems of its own. The system only works if people are willing to contribute ratings. In contributing ratings, of course, they are both doing the community a service and tuning their own interest profiles. The statistical error in correlating people's interests decreases as the number of ratings increases. However, incentives may have to be offered to encourage people to contribute ratings.

To bootstrap the accumulation of ratings for new items, an independent mechanism must exist to distribute them to a critical mass of people. Conversely, to bootstrap the accumulation of interest profiles for new users, an independent mechanism must exist to distribute a critical mass of items to them.

To allow meaningful accumulation of ratings, a sufficient period of time must be allowed to elapse. This may conflict with the timely delivery of items in question.

The statistical correlation between different people's interests, represented by their rating histories, is most meaningful when the ratings apply to homogeneous items. For a set of heterogeneous items, collaborative filtering is best applied to homogeneous subsets.

In a news setting, collaborative filtering is best applied to feature articles. Features have the longer life span required to support the accumulation of ratings, and are often appreciated for abstract qualities best singled out by collaborative filtering (good writing, humor, incisiveness, etc.).

Naturally, the larger a publication's readership, and the better its taste in relation to a potential reader, the stronger the publication's brand will appear to that reader.

Although it's easy to become preoccupied with automatic filtering, in reality there's more to editing the news than just filtering news feeds. An editor also solicits news, commissions analysis, and offers opinion, ideally ensuring that the publication offers a balanced and complete view of the world.

Perhaps the most important personalization step a reader takes is in selecting a particular publication from a set of available publications, based on its perceived quality and relevance.

Thus the publication's brand equates to the highest-level and most useful filter of all.

ARCHITECTURE

5   Netpage System Architecture

5.1   THE INTERNET

The Internet is a worldwide collection of interconnected networks which communicate using the TCP/IP protocol suite [77]. A TCP/IP-based internetwork not connected to *the* Internet is often referred to as *an* internet (i.e. with a lower-case 'i'). When an internet is deployed within an organization, it is often termed an intranet.

Access to the Internet is widespread in developed countries. In the United States, for example, 41% of the population has access to the Internet [69].

While most consumers still access the Internet via low-speed dial-up modems connected to the switched telephone system, inexpensive broadband access is becoming available to a growing number of households via the cable networks. Cable service is available to 95% of American households [75], and cable modem service is available to a 20% subset [13]. While dial-up modems offer speeds of up to 56Kbps, cable modems offer practical speeds of up to about 3Mbps[1], i.e. over 50 times faster.

DSL (Digital Subscriber Line) [16,17], while offering similar speeds to cable modems but via the telephone system, is not yet widely used. ISDN (Integrated Services Digital Network), although widely used for corporate access, has had little consumer impact due to its high price and comparatively low performance.

The deployment of third-generation (3G) cellular telephony within the next few years will bring practical mobile broadband speeds of 2Mbps [27]. 3G cellular uses WCDMA (wideband code-division multiple access), a spread-spectrum technology. Satellite systems are arguably closer to offering even faster broadband Internet access [39,65,81].

The core of the Internet is made up of a number of independent high-speed fiber-optic networks connected into NAPs (Network Access Points) or peered directly. These have until recently used single-wavelength TDM (Time-Division Multiplexing) SONET (Synchronous Optical Network) transmission systems which utilize about 1% of an optic fiber's capacity to yield a 2.5Gbps OC-48 channel[2]. Carriers are now beginning to deploy multi-wavelength DWDM (Dense Wavelength-Division Multiplexing) systems which yield up to 40 such channels per optic fiber, thus increasing network capacity significantly without requiring the laying of more fiber [14,52]. Internet architects are therefore now contemplating aggregate capacity in the terabit (Tbps) range.

The Internet uses the four-layer TCP/IP protocol suite. The application layer provides various end-to-end application services, and is a client of the transport layer which provides end-to-end delivery services. The transport layer in turn is a client of the network layer which provides packet routing. The network layer is a client of the link layer which encapsulates specifics of the protocols and hardware of the actual communications links.

The core Internet transport protocol, TCP (Transmission Control Protocol), provides a reliable end-to-end delivery service. The core Internet network protocol, IP (Internet Protocol), provides an unreliable and connectionless packet routing service. IP may lose or

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1. Although the cable supports 30Mbps and the cable modem theoretically supports 10Mbps.
2. SONETchannels have an OC-*n* designation, where OC stands for Optical Carrier, and *n* gives the channel speed in units of about 52Mbps. An OC-48 channel therefore has a speed of about 2.5Gbps.

      1 June 1999

deliberately discard packets, and may deliver packets out of order, and it is the responsibility of a higher layer to provide a reliable end-to-end service.

With the proliferation of streaming media services on the Internet, support for multicast is spreading rapidly. Multicast is a form of broadcast with a specific set of recipients. It makes efficient use of network capacity because a packet traverses a network link once rather than once per recipient. It is particularly efficient if the recipients are connected to the Internet via an intrinsically broadcast medium such as cable or satellite. The @Home cable network has successfully enabled multicasting of streaming media services [50].

IP Multicast is an extension of IP, and so is unreliable. While this is often acceptable for time-critical data such as streaming video, it may not be acceptable for other shared data types. Significant effort is being expended to develop reliable multicast transport protocols on top of IP Multicast. Although several reliable multicast protocols are available and have been deployed [55,56,41,42], the Internet standardization process is incomplete [43].

5.2 NETPAGES AND NETPAGE DOCUMENTS

Netpages are the foundation on which a Netpage Network is built. They provide a paper-based user interface to published information and interactive services.
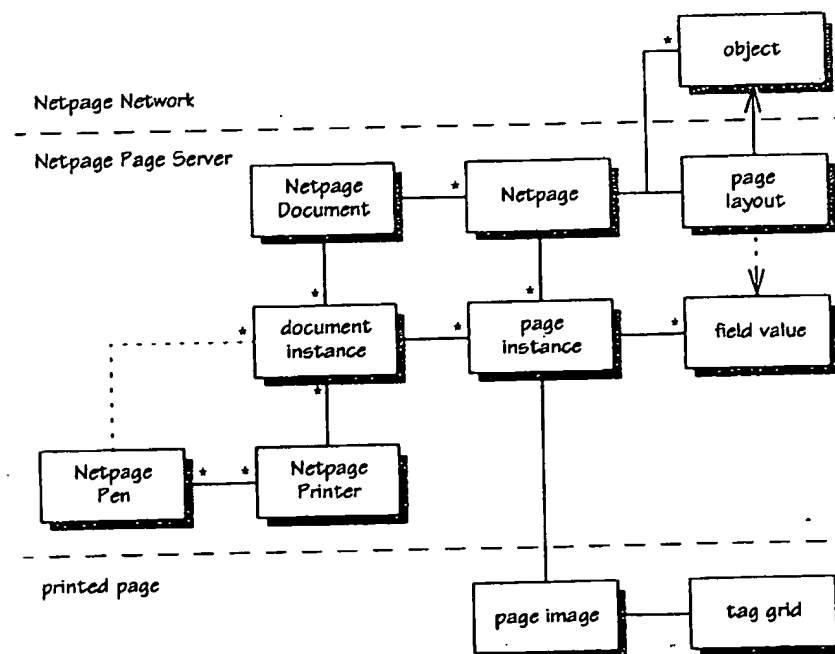

Figure 1. Netpage Document structure (* Indicates an n-ary relationship)

Each Netpage consists of a compact page layout maintained persistently by a Netpage Page Server. The page layout refers to objects such as images, fonts and pieces of text, typically stored elsewhere on the Netpage Network.

Netpages are organized into Netpage Documents. Both Netpages and Netpage Documents are assigned globally unique identifiers.

Each Netpage Document has a set of document instances, each of which describes a printed instance of the document. Each Netpage in the Netpage Document has a corresponding set of page instances, each of which describes a printed instance of the page. Both page instances and document instances are assigned globally unique identifiers. They are also uniquely associated with the printer on which they are printed, and the pen which initiated the print request, if known.

Each page instance maintains a set of user-supplied values for fields in the page layout. This ensures that user input is captured and stored independently for each page instance. The separation of page instances and Netpages is crucial for pages which contain input fields, i.e. forms. It is not crucial for pages devoid of input fields, but still useful because it supports independent auditing of each page instance.

The physical page image includes encoded information which identifies the page instance and hence the Netpage to which it corresponds. It also includes encoded information which superimposes an addressable spatial grid over the page image, to allow pen actions performed relative to the page image to be correlated with the contents of the page layout.

The encoded information is normally printed in infrared-absorptive ink on any normal paper substrate which is infrared-reflective. Near-infrared wavelengths are invisible to the human eye but are easily sensed by a solid-state image sensor with an appropriate filter.

The encoded information is picked up by an infrared-imaging pen and transmitted to the associated Netpage Printer. The pen is wireless and communicates with the Netpage Printer using an encrypted radio frequency signal.

The encoded information is organized as a set of tags, each containing both the id of the page instance and the position of the tag. The tags tile the entire page image, and are sufficiently small and densely arranged that the pen can reliably image at least one tag even on a single click on the page. It is important that the pen recognize the page instance id and position on every interaction with the page, since the interaction is stateless.

The tags are error-correctably encoded to make them resilient to errors introduced by dirt on the page or during the imaging process.

Memjet-based Netpage Printers are designed to print a tag grid using infrared (IR) ink. Printers not enabled for IR printing have the option to print tags using IR-absorptive black ink, although this restricts tags to otherwise empty areas of the page. Although such pages have more limited functionality than IR-printed pages, they are still classed as Netpages.

5.3   THE NETPAGE NETWORK

A Netpage Network consists of a distributed set of Netpage Publication Servers, Netpage Page Servers, and Netpage Printers connected via an internet. In technological terms this document describes *any* Netpage Network. In business terms it usually refers to *the* Netpage Network connected via *the* Internet.

As indicated above, a Netpage Page Server maintains persistent information about Netpage Documents, Netpages, and their printed instances, to allow pen operations on printed pages to be interpreted intelligently.

The Netpage Network includes any number of Netpage Page Servers, each handling a subset of Netpages. As indicated above, each page instance is identified by a globally unique

id which is encoded in the tag grid of the corresponding printed page. The Netpage Printer uses this id to retrieve the page layout of the page from a Netpage Page Server when it needs to interpret pen operations relative to the page.

The Netpage Printer uses the internet Distributed Name System (DNS) to resolve a Netpage instance id into a page instance maintained by a particular Netpage Page Server.

The DNS is a protocol and a hierarchical system of name servers used to resolve internet domain names into resources. Planned enhancements to the DNS allow it to be used to resolve more general Uniform Resource Identifiers (URIs), and in particular Uniform Resource Names (URNs), into resource locations [24]. Netpage instance ids are formulated as URNs, allowing the enhanced DNS to be used to resolve them. In the absence of timely standardization and deployment of an enhanced DNS on the Internet, the Netpage Network can deploy its own system of enhanced name servers.

A Netpage Publication Server is an internet server which publishes Netpage Documents to Netpage Printers. It is described in Section 6.

5.4   THE NETPAGE PRINTER

The Netpage Printer is the appliance which prints Netpage Documents. It is connected to a Netpage Network via an internet, ideally via a broadband connection.

Apart from identity and security settings in non-volatile memory, the Netpage Printer contains no persistent storage. As far as a user is concerned, *the network is the computer* [79]. Netpages function interactively across space and time with the help of the distributed Netpage Page Servers, independently of particular Netpage Printers.

The Netpage Printer receives Netpage Documents from Netpage Publication Servers. Each document is distributed in two parts: the page layouts, and the actual text and image objects which populate the pages. Because of personalization, page layouts are typically specific to a particular subscriber and so are pointcast to the subscriber's printer. Text and image objects, on the other hand, are typically shared with other subscribers, and so are multicast to all subscribers' printers.

The Netpage Publication Server optimizes the segmentation of document content into pointcasts and multicasts. After receiving the pointcast of a document's page layouts, the printer knows which multicasts, if any, to listen to.

Once the printer has received the entire document's page descriptions, i.e. page layouts *and* objects, it can print the document.

The printer rasterizes and prints odd and even pages simultaneously on both sides of the sheet. It therefore contains duplexed print engines and imaging units.

The printing process consists of two decoupled stages: rasterization of page descriptions, and expansion and printing of page images. The raster image processor (RIP) consists of one or more standard DSPs running in parallel. The duplexed print engines consist of custom processors which expand, dither and print page images in real time, synchronized with the operation of the printheads in the imaging units.

There are four major design variations embodied in the various Netpage Printer models:

- *form factor*: pocket, portable, desktop, wall-mount or tabletop
- *printhead width*: 4" (photo), 8½" (portrait Letter) or 11" (landscape Letter)
- *paper source*: cut sheet or print cartridge
- *Internet connection*: wired or wireless

This form factor variations yield five basic models, each with variants determined by printhead width (and hence printing speed), and paper source. Eight planned models are defined in Table 1, and illustrated in Figure 2.

Table 1. Netpage Printer models

model	form factor	variant	printhead width	paper source	Internet connect
Microprinter	pocket	R	4"	cartridge	wireless
Travelprinter	portable	R	8½"	cartridge	wireless
Deskprinter	desktop	R		cartridge	wired
Wallprinter	wall-mount	-		cut sheet	or
		Pro	11"	cut sheet	wireless
		Pro R		cartridge	
Tableprinter	tabletop	Pro		cut sheet	
		Pro R		cartridge	

The Deskprinter, Wallprinter and Tableprinter models can be factory-configured with various network modules, allowing both wired and wireless versions. The Microprinter and Travelprinter both use a cellular telephone module, with the promise of broadband speed within a few years.

The Wallprinter models are ideal for unobtrusive installation in a home, while the Tableprinter models might be preferred in an office environment. Note that the Tableprinter models are Wallprinter models factory-adapted for tabletop use via a stand. The Deskprinter, with its small footprint, is ideal for both home and office use.

The Microprinter prints normal Netpages at quarter size, and provides full wireless Netpage Network access in a pocket device.

The paper roll cartridge contains both paper and ink. The paper is in the form of a continuous roll, cut on demand by the printer. The 11" print cartridge has a capacity of 1000 Letter sheets. It also contains the glue supply for binding the sheets of a document together. The 8½" print cartridge has a capacity of 50 Letter sheets, or equivalently 100 A5 sheets. The 4" print cartridge has a capacity of 36 6×4 photos, or 41 quarter-size Netpages. The 8½" and 4" print cartridges don't contain a glue supply because neither the Microprinter nor the Travelprinter includes a binding mechanism.

The 4" printhead models print at 30 quarter-size pages per minute. The 8½" printhead models print at 60 pages per minute, or 30 duplex sheets per minute. The 11" printhead models print at 90 pages per minute, or 45 duplex sheets per minute.
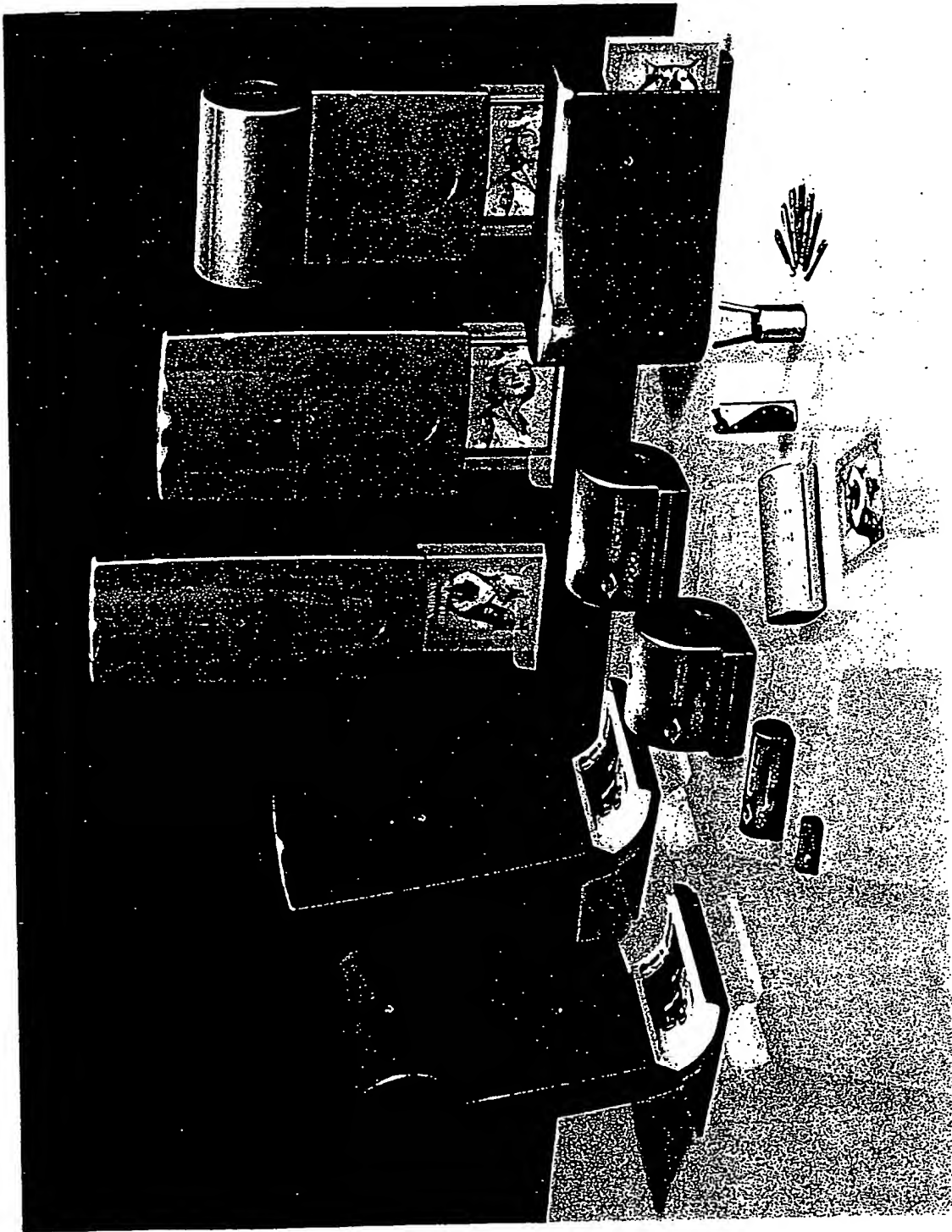
Figure 2. Netpage Printer family

5.5   THE NETPAGE PEN

The Netpage Pen operates both as a normal marking ink pen and as a non-marking stylus. When either nib is in contact with a Netpage, the pen continuously monitors its movements relative to the page. The nib is attached to a pressure sensor. The pen pressure can be interpreted relative to a threshold to indicate whether the pen is "up" or "down". It can also be interpreted as a continuous value, for example when the pen is capturing a signature, to allow the full dynamics of the signature to be verified.

The pen determines the position of its nib on the Netpage by imaging, in the infrared spectrum, an area of the page in the vicinity of the nib. It decodes the nearest page id and position tag, and adjusts the position given by the tag to account for the distance between the area imaged and the actual nib, and the position of the tag in the imaged area. Although the position resolution of the tag may be low, because the tag density on the page is inversely proportional to the tag size, the adjusted position resolution is quite high, and easily exceeds the minimum 200 dpi resolution required for handwriting recognition [80].

Pen actions relative to a Netpage consist of a series of strokes. A stroke consists of a sequence of time-stamped pen positions on the page, initiated by a pen-down event and completed by the subsequent pen-up event. A stroke is also tagged with the page id of the Netpage whenever the page id changes, i.e. just at the start of the stroke under normal circumstances.

The position tags on the Netpage contain various control bits. One of these instructs the pen to activate its "active area" LED. Thus a region on the page which corresponds to the active area of a button or hyperlink can be encoded to activate this LED, giving the user visual feedback that the button or hyperlink is active when the pen passes over it. Another control bit instructs the pen to capture continuous pen pressure readings and tag the stroke with these readings. Thus a region on the page which corresponds to a signature input area can be encoded to capture continuous pen pressure.

Whenever the pen is within range of a printer with which it can communicate, the pen slowly flashes its "online" LED. When the pen fails to decode a stroke relative to the page, it momentarily activates its "error" LED. When the pen succeeds in decoding a stroke relative to the page, it momentarily activates its "ok" LED.

The pen also contains a pair of passive accelerometers mounted at right angles to each other in the plane normal to the pen's axis. The accelerometers respond to gravity and allow the pen to compute its tilt. This in turn helps it auto-focus its optics and compute the nib-to-tag displacement. If the stroke is being tagged with pen pressure readings, then it is also tagged with tilt readings.

A sequence of captured strokes, whether tagged with pen pressure and tilt or not, is referred to as *digital ink*. Digital ink forms the basis for the digital exchange of drawings and handwriting, for on-line recognition of handwriting [80], and for on-line verification of signatures.

The pen is wireless and transmits digital ink to the Netpage Printer using a radio frequency signal. The digital ink data is encrypted for security and packetized for efficient transmission, but is always flushed on a pen-up event to ensure timely handling in the printer.

When the pen is out-of-range of a printer it buffers digital ink in internal memory, which has a capacity of more than 12 minutes of continuous handwriting. When the pen is once again within range of a printer, it transfers any buffered digital ink.

A pen can be registered with any number of printers, but because all state data resides in Netpages both on paper and on the network, it is largely immaterial which printer a pen is communicating with at any particular time.

5.6 NETPAGE INTERACTION

When the Netpage Printer receives a digital ink stroke from the pen, it retrieves the page layout of the Netpage identified in the stroke, to allow it to correctly interpret the stroke. The printer resolves, via the DNS, the address of the Netpage Page Server which holds the page layout, and then retrieves the page layout from the server. If the page was recently identified in an earlier stroke, then the printer may already have the address of the relevant Netpage Page Server in its cache. It may also have the page layout itself in its cache, in which case there may be no need to retrieve it.

Once the printer has the page layout of the Netpage to which the pen stroke refers, it can interpret the stroke in relation to the layout and content of the page. This involves hit-testing the objects on the page to determine which objects the pen is interacting with, in much the same way that mouse movements and button presses are interpreted in a graphical user interface system.

A "click" is a stroke where the distance between the pen down position and the subsequent pen up position is less than some small maximum. An object which is activated by a click requires a click to be activated, i.e. a longer stroke is ignored. The failure of a pen action, such as a "sloppy" click, to register is indicated by the lack of response from the pen's "ok" LED.

There are two kinds of interactive objects on a Netpage: hyperlinks and form fields.

When a hyperlink is activated, the printer sends a request to a handler somewhere on the network. The handler is identified by a URI, and the URI is resolved in the normal way via the DNS. There are three types of hyperlinks: general hyperlinks, form hyperlinks, and selection hyperlinks. A general hyperlink may implement a request for a linked document, or may simply signal a preference to a server. A form hyperlink submits the corresponding form to a form handler. A selection hyperlink submits the current selection to a selection handler. If the current selection contains a single-word piece of text, for example, the selection handler may return a single-page document giving the word's meaning within the context in which it appears, or a translation into a different language. Each hyperlink type is characterized by what information is submitted to the handler.

Form fields come in four varieties: checkboxes, text areas, digital ink areas, and signature areas. A checkbox accepts a true or false value. Any mark (a tick, a cross, a stroke, a fill zigzag, etc.) captured in a checkbox area is assigned as a true value to the corresponding field. A text area accepts a text string. Any digital ink captured in a text area is automatically converted to text via on-line handwriting recognition and the text is assigned to the corresponding field. A digital ink area accepts raw digital ink. Any digital ink captured in a digital ink area is assigned to the corresponding field. A signature area accepts a handwritten signature. Any digital ink captured in a signature area is automatically verified and the resulting signature token is assigned to the corresponding signature field. Signature verification is discussed in more detail in Section 8.

"Editing" commands, such as strike-throughs indicating deletion, are also recognized in form fields.

Table 2. Summary of pen interactions with a Netpage

object	type	pen Input	action
hyperlink	general	click	submit action to handler via URI
	form	click	submit form to handler via URI
	selection	click	submit selection to handler via URI
form field	checkbox	any mark	set field value to true
	text area	handwriting	convert digital ink to text; assign text to field
	digital ink area	digital ink	assign digital ink to field
	signature area	signature	verify digital ink signature; assign signature token to field
none	-	circumscription	convert digital ink to region; select object(s) in region

Because the handwriting recognition algorithm works "on-line" (i.e. with access to the dynamics of the pen movement), rather than "off-line" (i.e. with access only to a bitmap of pen markings), it can recognize run-on discretely-written characters [80] with high accuracy, without a writer-dependent training phase.

Digital ink, as already stated, consists of a sequence of strokes. Any stroke which starts in a particular object's active area is appended to that area's digital ink stream, ready for eventual interpretation. Any stroke not appended to an object's digital ink stream is appended to the remaining inactive area's digital ink stream.

Digital ink captured in the inactive area is interpreted as a selection gesture. Any circumscription of one or more objects is interpreted as a selection of the circumscribed objects.

The printer maintains a current selection for each pen. The selection contains the most recent object selected, resolved with reference to the page layout and content. The selection can be attached to or pasted into another form, or in general be submitted to a selection handler as described earlier. The selection is cleared after an inactivity time-out to ensure predictable behavior.

Table 2 provides a summary of pen interactions with a Netpage.

5.7 FORMS

As described in Section 5.2, user input on a physical Netpage is ultimately recorded persistently by a Netpage Page Server together with the corresponding page instance. To ensure efficient capture of user input, the printer accumulates input locally. To prevent update anomalies, however, the printer temporarily obtains exclusive access to the page instance from the Netpage Page Server. The printer flushes input back to the server and relinquishes exclusive access when the user initiates a non-local action on the page; after an inactivity time-out on the page; when the printer wishes to free up local storage consumed by the page; and on request from the server.

When the printer submits a form to a form handler, it simply submits the document instance of the form. The form handler retrieves the field values from the Netpage Page Server at its leisure.

A form can also act as a shared "blackboard" between the user and the form handler, i.e. the form handler can query the contents of the form fields maintained by the Netpage Page Server without the user explicitly submitting the form.

For text areas, the raw digital ink is optionally also stored with the page instance on the Netpage Page Server. This allows the form handler to interrogate the raw digital ink should it suspect the original recognition of the handwriting. This might involve human intervention at the application level for forms which fail certain application-specific consistency checks. As an extension to this, the entire background area of a form can be designated as a digital ink area. The form handler can then decide, on the basis of the presence of digital ink outside the explicit fields of the form, to route the form to a human operator, on the assumption that the user may have indicated amendments to the filled-in fields outside of those fields.

Form fields can optionally be tagged to indicate their meaning. Fields tagged in this way may include name and address fields, for example. This semantic tagging allows these fields to be automatically filled in whenever a "blank" form is requested by an identifiable user, i.e. a user who has registered their identity with the system and linked it to the identity of their pen.

5.8   STANDARD FEATURES OF NETPAGES

Each Netpage is printed with the Netpage logo at the bottom to indicate that it is a Netpage and therefore has interactive properties. The logo also acts as a "copy" button. In most cases pressing the logo produces a copy of the page. In the case of a form the button instead elicits a page giving the user the option to print the entire form document. And in the case of a secure document, such as a ticket or coupon, the button elicits an explanatory note or advertising page.

The default single-page copy function is handled directly by the relevant Netpage Page Server. Special copy functions are handler by linking the logo button to other URIs.

Once a Netpage form has been submitted, it is marked as submitted by the Netpage Page Server and cannot be submitted again. An attempt to do so elicits a status report indicating when it was submitted. A copy of the form can still be made, altered, and re-submitted.

5.9   THE HELP SYSTEM

The Netpage Printer has a single button labelled "help". When pressed it elicits a single page of information. This information includes the following:

- status of printer connection
- status of printer consumables
- top-level help menu
- document function menu
- top-level Netpage Network directory

The help menu provides a hierarchical manual on how to use the Netpage System.

The document function menu includes the following functions:

- print a copy of a document

- print a clean copy of a form
- print the status of a document

A document function is initiated by simply pressing the button and then touching any page of the document. The status of a document indicates who published it and when, to whom it was delivered, and to whom and when it was subsequently submitted as a form.

The Netpage Network directory allows the user to navigate the hierarchy of publications and services on the network. As an alternative, the user can call the Netpage Network "900" number "yellow pages" and speak to a human operator. The operator can locate the desired document and route it to the user's printer. Depending on the document type, the publisher or the user pays the small "yellow pages" service fee.

The help page is obviously unavailable if the printer is unable to print. In this case the "error" light is lit and the user can request remote diagnosis over the network.

6 Personalized Publication Model

In the following discussion, news is used as a canonical publication example to illustrate personalization mechanisms in the Netpage System. Although news is often used in the limited sense of newspaper and news magazine news, the intended scope is wider.

In the Netpage System, the editorial content and the advertising content of a news publication are personalized using different mechanisms. The editorial content is personalized according to the reader's explicitly stated and implicitly captured interest profile. The advertising content is personalized according to the reader's locality and demographic.

6.1 EDITORIAL PERSONALIZATION

A subscriber can draw on two kinds of news sources: those that deliver news publications, and those that deliver news streams. While news publications are aggregated and edited by the publisher, news streams are aggregated either by a news publisher or by a specialized news aggregator. News publications typically correspond to traditional newspapers and news magazines, while news streams can be many and varied: a "raw" news feed from a news service, a cartoon strip, a freelance writer's column, a friend's bulletin board, or the reader's own e-mail.

The Netpage Publication Server supports the publication of edited news publications as well as the aggregation of multiple news streams. By handling the aggregation and hence the formatting of news streams selected directly by the reader, the server is able to place advertising on pages over which it otherwise has no editorial control.

The subscriber builds a daily newspaper by selecting one or more contributing news publications, and creating a personalized version of each. The resulting daily editions are printed and bound together into a single newspaper. The various members of a household typically express their different interests and tastes by selecting different daily publications and then customizing them.

For each publication, the reader optionally selects specific sections. Some sections appear daily, while others appear weekly. The daily sections available from The New York Times online, for example, include "Page One Plus", "National", "International", "Opinion", "Business", "Arts/Living", "Technology", and "Sports". The set of available sections is obviously specific to a publication, as is the default subset.

The reader extends the daily newspaper by creating custom sections, each one drawing on any number of news streams. Custom sections might be created for e-mail and friends' announcements ("Personal"), or for monitoring news feeds for specific topics ("Alerts" or "Clippings").

For each section, the reader optionally specifies its size, either qualitatively (e.g. short, medium, or long), or numerically (i.e. as a limit on its number of pages), and the desired proportion of advertising, either qualitatively (e.g. high, normal, low, none), or numerically (i.e. as a percentage).

The reader also optionally expresses a preference for a large number of shorter articles or a small number of longer articles. Each article is ideally written (or edited) in both short and long forms to support this preference.

An article may also be written (or edited) in different versions to match the expected sophistication of the reader, for example to provide children's and adults' versions. The appropriate version is selected according to the reader's age. The reader can specify a "reading age" which takes precedence over their biological age.

The articles which make up each section are selected and prioritized by the editors, and each is assigned a useful lifetime. By default they are delivered to all relevant subscribers, in priority order, subject to space constraints in the subscribers' editions.

In sections where it is appropriate, the reader may optionally enable collaborative filtering. This is then applied to articles which have a sufficiently long lifetime. Each article which qualifies for collaborative filtering is printed with rating buttons at the end of the article. The buttons can provide an easy choice (e.g. "liked" and "disliked'), making it more likely that readers will bother to rate the article.

Articles with high priorities and short lifetimes are therefore effectively considered essential reading by the editors and are delivered to most relevant subscribers.

The reader optionally specifies a serendipity factor, either qualitatively (e.g. do or don't surprise me), or numerically. A high serendipity factor lowers the threshold used for matching during collaborative filtering. A high factor makes it more likely that the corresponding section will be filled to the reader's specified capacity. A different serendipity factor can be specified for different days of the week.

The reader also optionally specifies topics of particular interest within a section, and this modifies the priorities assigned by the editors.

The speed of the reader's Internet connection affects the quality at which images can be delivered. The reader optionally specifies a preference for fewer images or smaller images or both. If the number or size of images is not reduced, then images may be delivered at lower quality (i.e. at lower resolution or with greater compression).

At a global level, the reader specifies how quantities, dates, times and monetary values are localized. This involves specifying whether units are imperial or metric, a local timezone and time format, and a local currency, and whether the localization consist of *in situ* translation or annotation. These preferences are derived from the reader's locality by default.

To reduce reading difficulties caused by poor eyesight, the reader optionally specifies a global preference for a larger presentation. Both text and images are scaled accordingly, and less information is accommodated on each page.

The language in which a news publication is published, and its corresponding text encoding, is a property of the publication and not a preference expressed by the user. However, the Netpage Network may provide automatic translation services in various guises.

6.2   ADVERTISING LOCALIZATION AND TARGETING

The personalization of the editorial content directly affects the advertising content, because advertising is typically placed to exploit the editorial context. Travel ads, for example, are more likely to appear in a travel section than elsewhere. The value of the editorial content to an advertiser (and therefore to the publisher) lies in its ability to attract large numbers of readers with the right demographics.

Effective advertising is placed on the basis of locality and demographics. Locality determines proximity to particular services, retailers etc., and particular interests and concerns associated with the local community and environment. Demographics determine general interests and preoccupations as well as likely spending patterns.

A news publisher's most profitable product is advertising "space", a multi-dimensional entity determined by the publication's geographic coverage, the size of its readership, its readership demographics, and the page area available for advertising.

In the Netpage System, the Netpage Publication Server computes the approximate multi-dimensional size of a publication's saleable advertising space on a per-section basis, taking into account the publication's geographic coverage, the section's readership, the size of each reader's section edition, each reader's advertising proportion, and each reader's demographic.

In comparison with other media, the Netpage System allows the advertising space to be defined in greater detail, and allows smaller pieces of it to be sold separately. It therefore allows it to be sold at closer to its true value.

For example, the same advertising "slot" can be sold in varying proportions to several advertisers, with individual readers' pages randomly receiving the advertisement of one advertiser or another, overall preserving the proportion of space sold to each advertiser.

The Netpage System allows advertising to be linked directly to detailed product information and online purchasing. It therefore raises the intrinsic value of the advertising space.

Because personalization and localization are handled automatically by Netpage Publication Servers, an advertising aggregator can provide arbitrarily broad coverage of both geography and demographics. The subsequent disaggregation is efficient because it is automatic. This makes it more cost-effective for publishers to deal with advertising aggregators than to directly capture advertising. Even though the advertising aggregator is taking a proportion of advertising revenue, publishers may find the change profit-neutral because of the greater efficiency of aggregation. The advertising aggregator acts as an intermediary between advertisers and publishers, and may place the same advertisement in multiple publications.

It is worth noting that ad placement in a Netpage publication can be more complex than ad placement in the publication's traditional counterpart, because the publication's advertising space is more complex. While ignoring the full complexities of negotiations between advertisers, advertising aggregators and publishers, it is clear that the Netpage System should ideally provide some automated support for these negotiations, including support for automated auctions of advertising space. Automation is particularly desirable for the placement of advertisements which generate small amounts of income, i.e. small or highly localized advertisements.

Once placement has been negotiated, the aggregator captures and edits the advertisement and records it on a Netpage Ad Server. Correspondingly, the publisher records the ad placement on the relevant Netpage Publication Server. When the Netpage Publication Server lays out each user's personalized publication, it picks the relevant advertisements from the Netpage Ad Server.

6.3   USER PROFILES

The personalization of news and other publications relies on an assortment of user-specific profile information:

- publication customizations
- collaborative filtering vectors
- contact details
- presentation preferences

The customization of a publication is typically publication-specific, and so the customization information is maintained by the relevant Netpage Publication Server.

A collaborative filtering vector consists of the user's ratings of a number of news items. As described in Section 4, it is used to correlate different users' interests for the purposes of making recommendations. Although there are benefits to maintaining a single collaborative filtering vector independently of any particular publication, there are two reasons why it is more practical to maintain a separate vector for each publication: there is likely to be more overlap between the vectors of subscribers to the same publication than to different publications; and a publication is likely to want to present its users' collaborative filtering vectors as part of the value of its brand, not to be found elsewhere. Collaborative filtering vectors are therefore also maintained by the relevant Netpage Publication Server.

Contact details, including name, street address, ZIP code, state, country, telephone numbers, etc., are by their nature global and are maintained by a Netpage Registration Server.

Presentation preferences, including those for quantities, dates and times discussed in Section 6.1, are likewise global and maintained in the same way.

The localization of advertising relies on the locality indicated in the user's contact details, while the targeting of advertising relies on personal information such as date of birth, gender, marital status, income, profession, education, etc., or qualitative derivatives such as age range and income range.

For those users who choose to reveal personal information for advertising purposes, the information is maintained by the relevant Netpage Registration Server. In the absence of such information, advertising can be targeted on the basis of the demographic associated with the user's ZIP or ZIP+4 code.

Each user, pen and printer is assigned a globally unique identifier, and the Netpage Registration Server maintains the relationships between them. The server also keeps track of which publications a user has authorized to print on particular printers. Each user may have several pens, but a pen is specific to a single user. A pen may know any number of printers, and a printer may know any number of pens. These relationships are illustrated in Figure 3.
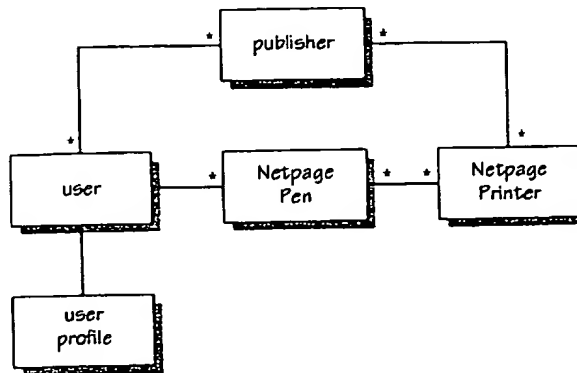
Figure 3. User registration relationships

The pen identifier is used, in the form of a URN, to locate the corresponding user profile maintained by a particular Netpage Registration Server, via the DNS in the usual way.

6.4   INTELLIGENT PAGE LAYOUT

The Netpage Publication Server automatically lays out the pages of each user's personalized publication on a section-by-section basis. Since most advertisements are in the form of pre-formatted rectangles, they are placed on the page before the editorial content.

The advertising ratio for a section can be achieved with wildly varying advertising ratios on individual pages within the section, and the ad layout algorithm exploits this. The algorithm attempts to co-locate closely tied editorial and advertising content, e.g. ads for roofing material placed specifically with the publication because of a special feature on. do-it-yourself roofing repairs.

The editorial content selected for the user, i.e. text with associated images and graphics, is then laid out according to various aesthetic rules.

The entire process, including the selection of ads and the selection of editorial content, must be iterated once the layout has converged, to attempt to more closely achieve the user's stated section size preference. The section size preference can, however, be matched *on average* over time, allowing significant day-to-day variations.

6.5   DOCUMENT FORMAT

Once the document is laid out, it is encoded for efficient distribution and persistent storage on the Netpage Network.

The primary efficiency mechanism is the separation of information specific to a single user's edition and information shared between multiple users' editions. The specific information consists of the page layout. The shared information consists of the objects to which the page layout refers, including images, graphics, and pieces of text.

A text object contains fully-formatted text represented in the Extensible Markup Language (XML) [92] using the Extensible Stylesheet Language (XSL) [93]. XSL provides precise control over text formatting independently of the region into which the text is

being set, which in this case is being provided by the layout. The text object contains embedded language codes to enable automatic translation, and embedded hyphenation hints to aid with paragraph formatting.

An image object encodes an image in the JPEG 2000 wavelet-based compressed image format [46]. The original DCT-based JPEG algorithm introduces negligible visual loss at compression ratios below 10:1 [88]. JPEG 2000 is planned to achieve the same quality at compression ratios 30% higher, i.e. at about 13:1 [47].

A graphic object encodes a 2D graphic in Scalable Vector Graphics (SVG) [95] format.

The layout itself consists of a series of placed image and graphic objects, linked textflow objects through which text objects flow, hyperlinks and input fields as described in Section 5.6, and watermark regions. These layout objects are summarized in Table 3. The layout uses a compact format suitable for efficient distribution and storage.

The layout is tagged with the version of the text-setting algorithm used by the Netpage Publication Server when the layout was first created, allowing the Netpage Printer to exactly reproduce the physical layout intended by the server.

Because Netpage Printer software is automatically upgraded over the Netpage Network, it is feasible to for Netpage Printers to contain every version of the text-setting algorithm.

Table 3. Netpage layout objects

layout object	attribute	linked object format
image	position	-
	image object URI	JPEG 2000
graphic	position	-
	graphic object URI	SVG
textflow	textflow id	-
	region[a]	
	optional text object URI	XML/XSL
hyperlink	type	-
	region[a]	-
	handler URI	-
field	type	-
	meaning	
	region[a]	-
watermark	region[a]	-

a. arbitrary multi-edged shape defined with spline paths

6.6   DOCUMENT DISTRIBUTION

As described above, for purposes of efficient distribution and persistent storage on the Netpage Network, a user-specific page layout is separated from the shared objects to which it refers.

When a subscribed publication is ready to be distributed, the Netpage Publication Server allocates, with the help of the Netpage Id Server, a globally unique id for each page, page instance, document, and document instance.

The server computes a set of optimized subsets of the shared content and creates a multi-cast channel for each subset, and then tags each user-specific layout with the names of the multicast channels which will carry the shared content used by that layout. The server then pointcasts each user's layouts to that user, and when the pointcasting is complete, multi-casts the shared content on the specified channels. After receiving its pointcast, each Netpage Printer subscribes to the multicast channels specified in the page layouts. During the multicasts, each printer extracts from the multicast streams those objects referenced by its page layouts.

Once a printer has received all the objects to which it page layouts refer, the printer re-creates the fully-populated layout and then rasterizes and prints it.

The server also delivers each page layout to the relevant Netpage Page Server, which may be co-located with the Netpage Publication Server, or may be located elsewhere on the network. Thus the page layouts are persistently archived as Netpages. It is the responsibility of the Netpage Publication Server to preserve the shared objects referenced by the Netpages, to ensure that they are really persistent. It may choose to archive these shared objects elsewhere on the network at any time. The object URIs embedded in the Netpages allow the objects to move.

Under normal circumstances, the printer prints page faster than they can be delivered. Assuming a quarter of each page is covered with images, the average page has a size of less than 400KB[1]. The printer can therefore hold in excess of 100 such pages in its internal 64MB memory, allowing for temporary buffers etc. The printer prints at a rate of one page per second. This is equivalent to 400KB or about 3Mbit of page data per second, which is similar to the highest expected rate of page data delivery over a broadband network.

Even under abnormal circumstances, such as when the printer runs out of paper, it is likely that the user will be able to replenish the paper supply before the printer's 100-page internal storage capacity is exhausted.

However, if the printer's internal memory does fill up, then the printer will be unable to make use of a multicast when it first occurs. The Netpage Publication Server therefore allows printers to submit requests for re-multicasts. When a critical number of requests is received or a timeout occurs, the server re-multicasts the corresponding shared objects.

Once a document is printed, a Netpage Printer can produce an exact duplicate at any time by retrieving its page layouts from the relevant Netpage Page Server and retrieving the objects to which they refer from the network.

6.7   ON-DEMAND DOCUMENTS

When a Netpage document is requested ad hoc, it is personalized and delivered in much the same way as a periodical. However, since there is no shared content, delivery is made directly to the requesting printer, i.e. without the use of multicast.

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1. 267 pixels per inch (ppi) 24-bit RGB, compressed using JPEG 2000 at a ratio of 13:1.

When a non-Netpage document is requested ad hoc, it is not personalized, and it is delivered via a designated Netpage Formatting Server which reformats it as a Netpage document. A Netpage Formatting Server is a special instance of a Netpage Publication Server. The Netpage Formatting Server has knowledge of myriad Internet document formats, including old favorites such as Adobe's Portable Document Format (PDF) [5], and Hypertext Markup Language (HTML) [94]. In the case of HTML, it makes use of the higher resolution of the printed page to present Web pages in a two-column format, with a table of contents and an index of links. By default it automatically includes all Web pages directly linked to the requested page. The user can tune this behavior via a preference.

The Netpage Formatting Server makes standard Netpage behavior, including interactivity and persistence, available on any Internet document, no matter what its origin and format. It hides knowledge of different document formats from both the Netpage Printer and the Netpage Page Server.

7   Security

7.1   CRYPTOGRAPHY

Cryptography is used to protect sensitive information, both in storage and in transit, and to authenticate parties to a transaction. There are two classes of cryptography in widespread use: secret-key cryptography and public-key cryptography. The Netpage Network uses both classes of cryptography.

Secret-key cryptography, also referred to as symmetric cryptography, uses the same key to encrypt and decrypt a message. Two parties wishing to exchange messages must first arrange to securely exchange the secret key.

Public-key cryptography, also referred to as asymmetric cryptography, uses of two encryption keys. The two keys are mathematically related in such a way that any message encrypted using one key can only be decrypted using the other key. One of these keys is then published, while the other is kept private. The public key is used to encrypt any message intended for the holder of the private key. Once encrypted using the public key, a message can only be decrypted using the private key. Thus two parties can securely exchange messages without first having to exchange a secret key. To ensure that the private key is secure, it is normal for the holder of the private key to generate the key pair.

Public-key cryptography can be used to create a digital signature. If the holder of the private key creates a known hash of a message and then encrypts the hash using the private key, then anyone can verify that the encrypted hash constitutes the "signature" of the holder of the private key with respect to that particular message, simply by decrypting the encrypted hash using the public key and verifying the hash against the message. If the signature is appended to the message, then the recipient of the message can verify both that the message is genuine and that it has not been altered in transit.

To make public-key cryptography work, there has to be a way to distribute public keys which prevents impersonation. This is normally done using certificates and certificate authorities. A certificate authority is a trusted third party which authenticates the connection between a public key and someone's identity. The certificate authority verifies the person's identity by examining identity documents etc., and then creates and signs a digital certificate containing the person's identity details and public key. Anyone who trusts the certificate authority can use the public key in the certificate with a high degree of certainty that it is genuine. They just have to verify that the certificate has indeed been signed by the certificate authority, whose public key is well-known.

In most transaction environments, public-key cryptography is only used to create digital signatures and to securely exchange secret session keys. Secret-key cryptography is used for all other purposes.

In the following discussion, when reference is made to the *secure* transmission of information between a Netpage Printer and a server, what actually happens is that the printer obtains the server's certificate, authenticates it with reference to the certificate authority, uses the public key-exchange key in the certificate to exchange a secret session key with the server, and then uses the secret session key to encrypt the message data. A *session* key, by definition, can have an arbitrarily short lifetime.

7.2   NETPAGE PRINTER SECURITY

Each Netpage Printer is assigned a pair of unique identifiers at time of manufacture which are stored in read-only memory in the printer and in the Netpage Registration Server database. The first id is public and uniquely identifies the printer on the Netpage Network. The second id is secret and is used when the printer is first registered on the network.

When the printer connects to the Netpage Network for the first time after installation, it creates a signature public/private key pair. It transmits the secret id and the public key securely to the Netpage Registration Server. The server compares the secret id against the printer's secret id recorded in its database, and accepts the registration if the ids match. It then creates and signs a certificate containing the printer's public id and public signature key, and stores the certificate in the registration database.

The Netpage Registration Server acts as a certificate authority for Netpage Printers, since it has access to secret information allowing it to verify printer identity.

When a user subscribes to a publication, a record is created in the Netpage Registration Server database authorizing the publisher to print on a particular printer. Every document sent to a printer is signed by the publisher using the publisher's private signature key. The printer verifies via the registration database that the publisher is authorized to print on the printer, and verifies the signature using the publication's public key, obtained from the publisher's certificate stored in the registration database.

The Netpage Registration Server accepts requests to add printing authorizations to the database, so long as those requests are initiated via a pen registered to the printer.

7.2.1   Casual Printing Authorizations

The user can register a Web terminal as a "publisher" authorized to print on a printer. This is useful if the user has a Web terminal in the home which is used to locate documents on the Web for printing. The one-time authorization proceeds as follows: the user prints a Web terminal authorization form. The Netpage Registration Server generates a short-life-time one-time-use id for the Web terminal which is printed on the form, together with the URI of the printer. The Web terminal is used to navigate to a Netpage Registration Server registration site, where the one-time-use id is entered, as well as the URI of the printer. The Web terminal generates a signature public/private key pair. The server allocates a publisher id for the Web terminal, creates and signs a certificate containing the publisher id and the public key, and stores the certificate in the registration database. The URI of the printer, the Web terminal's publisher id, and the private signature key are stored locally on the Web terminal.

Whenever the Web terminal wishes to print on the printer, it sends the printer's designated Netpage Formatting Server a request containing the URI of the document to be printed, together with the publisher id, signed with the Web terminal's private signature key. On receipt of the request and before acting on it, the server verifies the publisher id and signature in the usual way.

The user can print a list of current printing authorizations at any time, and revoke any which are being abused.

The same scheme can be used to authorize other Netpage users to send greeting cards, e-mail, etc., to the printer. The user simply prints a one-time authorization "token". This is given to the other user, who simply presses the button on the token with their pen. The

system takes care of the rest, including adding each user's name to the other's address book.

Authorization tokens can be printed on the back of a user's business card, to provide casual but fairly controlled authorization. Recall that authorizations can be easily reviewed and selectively revoked.

A user can also choose to provide all users with greeting card, e-mail, etc., access to their Netpage Printer.

7.3   NETPAGE PEN SECURITY

Each Netpage Pen is assigned a unique identifier at time of manufacture which is stored in read-only memory in the pen and in the Netpage Registration Server database. The id uniquely identifies the pen on the Netpage Network.

A Netpage Pen can know a number of Netpage Printers, and a printer can know a number of pens. A pen communicates with a printer via a radio frequency signal whenever it is within range of the printer. Once a pen and printer are registered, they regularly exchange session keys. Whenever the pen transmits digital ink to the printer, it always uses the appropriate session key. Digital ink is never transmitted in the clear.

A pen stores a session key for every printer is knows, indexed by printer id, and a printer stores a session key for every pen it knows, indexed by pen id. Both have a large but finite storage capacity for session keys, and will forget a session key on a least-recently-used basis if necessary. If either a pen or a printer forgets the other, then they simply have to go though the automatic registration procedure again.

When an unknown pen comes within range of a printer, they soon discover they don't know each other. Under these circumstances the pen simply ignores the printer until it finds itself in the charging cup, at which time it initiates the registration procedure.

In addition to its public id, the pen contains a secret id and a secret key-exchange key, both intended for one-time use. These are also recorded in the Netpage Registration Server database at time of manufacture. During registration, the printer obtains the secret id from the pen. Because it is transmitted in the clear, it may be intercepted by someone listening in. The printer transmits the id securely to the Netpage Registration Server, which responds securely with the matching key-exchange key, together with a newly-generated secret id and key-exchange key. The printer generates a session key for the pen and transmits it to the pen encrypted using the one-time-use key-exchange key. It also securely transmits the new secret id and key-exchange key to the pen, which saves them for the next registration procedure. They now match the pen's record in the Netpage Registration Server database.

If the secret id transmitted in the clear from the pen to the printer is intercepted and used to retrieve the secret key-exchange key from the Netpage Registration Server before the printer queries the server, then the server rejects the printer's query because the secret id is out-of-date. Thus the printer knows that the pen has been compromised, and recommends that it be returned for repair.

Whenever a pen is registered, the Netpage Registration Server prints a registration form allowing the pen to be registered in the name of a user. The pen can be registered to an

existing user in the registration database, in which case the user's optional password may have to be provided, or new user details can be entered.

The pen uses secret-key rather than public-key encryption because of hardware performance constraints in the pen.

7.4   SECURE DOCUMENTS

The Netpage System supports the delivery of secure documents such as tickets and coupons. The Netpage Printer includes a facility to print watermarks, but will only do so on request from publishers who are suitably authorized. The publisher indicates its authority to print watermarks in its certificate, which the printer is able to authenticate.

The "watermark" printing process uses an alternative dither matrix in specified "watermark" regions of the page. Back-to-back pages contain mirror-image watermark regions which coincide when printed. The dither matrices used in odd and even pages' watermark regions are designed to produce an interference effect when the regions are viewed together - i.e. when looking *through* the printed sheet.

The effect is similar to a watermark in that it is not visible when looking at only one side of the page, and is lost when the page is copied by normal means.

As described in Section 5.8, pages of secure documents cannot be copied using the built-in Netpage copy mechanism. This extends to copying Netpages on Netpage-aware photocopiers.

Secure documents are typically generated as part of e-commerce transactions. They can therefore include the user's photograph which was captured when the user registered biometric information with the Netpage Registration Server, as described in Section 8.

When presented with a secure Netpage document, the recipient can verify its authenticity by requesting its status in the usual way. The unique id of a secure document is only valid for the lifetime of the document, and secure document ids are allocated non-contiguously to prevent their prediction by opportunistic forgers. A secure document verification pen can be developed with built-in feedback on verification failure, to support easy point-of-presentation document verification.

Clearly neither the watermark nor the user's photograph are secure in a cryptographic sense. They simply provide a significant obstacle to casual forgery. Online document verification, particularly using a verification pen, provides an added level of security where it is needed, but is still not entirely immune to forgeries.

7.5   NON-REPUDIATION

In the Netpage System, forms submitted by users are delivered reliably to forms handlers and are persistently archived on Netpage Page Servers. It is therefore impossible for recipients to repudiate delivery.

E-commerce payments made through the system, as described in Section 8, are also impossible for the payee to repudiate.

8   Electronic Commerce Model

8.1   SECURE ELECTRONIC TRANSACTION (SET)

The Netpage System uses the Secure Electronic Transaction (SET) [58] system as its payment system model. Although SET is not yet widely supported, it is comprehensive and elegant and will probably become dominant in the near future.

SET, having been developed by MasterCard and Visa, is organized around payment cards, and this is reflected in the terminology. However, much of the system is independent of the type of accounts being used.

In SET, cardholders and merchants register with a certificate authority and are issued with certificates containing their public signature keys. The certificate authority verifies a cardholder's registration details with the card issuer as appropriate, and verifies a merchant's registration details with the acquirer as appropriate. Cardholders and merchants store their respective private signature keys securely on their computers. During the payment process, these certificates are used to mutually authenticate a merchant and cardholder, and to authenticate them both to the payment gateway.

SET has not yet been adopted widely, partly because cardholder maintenance of keys and certificates is considered burdensome. Interim solutions which maintain cardholder keys and certificates on a server and give the cardholder access via a password have met with some success [18].

8.2   SET PAYMENTS

In the Netpage System the Netpage Registration Server acts as a proxy for the Netpage user (i.e. the cardholder) in SET payment transactions.

The Netpage System uses biometrics to authenticate the user and authorize SET payments. Because the system is pen-based, the biometric used is the user's on-line signature, consisting of time-varying pen position, tilt and pressure. A fingerprint biometric can also be used by designing a fingerprint sensor into the pen, although at a higher cost. The type of biometric used only affects the capture of the biometric, not the authorization aspects of the system.

The first step to being able to make SET payments is to register the user's biometric with the Netpage Registration Server. This is done in a controlled environment, for example a bank, where the biometric can be captured at the same time as the user's identity is verified. The biometric is captured and stored in the registration database, linked to the user's record and to the record of a particular Netpage Pen. The user's photograph is also optionally captured and linked to the record. The SET cardholder registration process is completed, and the resulting private signature key and certificate are stored in the database. The user's payment card information is also stored, giving the Netpage Registration Server enough information to act as the user's proxy in any SET payment transaction.

When the user eventually supplies the biometric to complete a payment, for example by signing a Netpage order form, the printer securely transmits the order information, the pen id and the biometric data to the Netpage Registration Server. The server verifies the biometric with respect to the user identified by the pen id, and from then on acts as the user's proxy in completing the SET payment transaction.

8.3   MICRO-PAYMENTS

The Netpage Network includes a mechanism for micro-payments, to allow the user to be conveniently charged for printing low-cost documents on demand and for copying copyright documents, and possibly also to allow the user to reimbursed for expenses incurred in printing advertising material. The latter depends on the level of subsidy already provided to the user.

When the user registers for e-commerce, a network account is established which aggregates micro-payments. The user receives a statement on a regular basis, and can settle any outstanding debit balance using the standard payment mechanism.

The network account can be extended to aggregate subscription fees for periodicals, which would also otherwise be presented to the user in the form of individual statements.

8.4   TRANSACTIONS

Whenever a transaction originates through a Netpage form, the form handler has sufficient information, in the shape of the form's unique document instance id, to maintain transaction-specific state information. However, a transaction may also originate through a non-form page such as a printed catalog page, implying, for example, the existence of a virtual "shopping trolley". In this case the relevant transaction state information is tied, indirectly, to the unique id of the user.

The Netpage Registration Server maintains an anonymous relationship between a user and a transaction handler via a uniquely numbered transaction, as illustrated in Figure 4. Whenever the user activates a hyperlink tagged with the "transaction" attribute, the Netpage Printer asks the Netpage Registration Server to translate the associated handler id, together with the pen id, into a transaction id. The transaction id is then submitted to the hyperlink transaction handler. For efficiency, the printer caches transaction ids.

The transaction handler maintains state information indexed by transaction id. It is able to retrieve user-specific state information without explicit knowledge of the user.
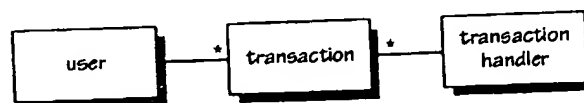
Figure 4. User transaction

APPLICATIONS AND BUSINESS MODELS

9   Applications

The Netpage Network has the potential to subsume a wide variety of applications in both traditional and electronic media. This section describes the following possibilities:

- personalized subscriptions to newspapers, magazines and comics
- subscriptions to freelance columns and bulletin boards
- on-demand newspapers, magazines and comics
- on-demand flyers and product brochures
- on-demand books
- television infotainment printing
- e-commerce purchasing from online and traditional catalogs
- delivery of statement and invoices, with online payment
- delivery of secure document (tickets, coupons and licenses)
- perfect copying with copyright micro-payments
- mail replacement
- delivery of greeting cards
- form printing, fill-in, and submission
- delivery of e-mail and facsimile
- on-demand document delivery on corporate intranets
- provision of government services
- Web browsing, searching and printing
- photo album creation
- persistent searchable note taking
- computer printing

9.1   PERSONALIZED SUBSCRIPTIONS

The strength of the Netpage Network lies in automatically delivering subscribed periodicals, at a print quality equalling or exceeding that of their traditional counterparts, with editorial content personalized to individual interests, advertising content localized and targeted to individual localities and demographics, and advertising directly linked to detailed product information and product purchasing.

9.1.1   Newspapers and Magazines

The Netpage Network offers a new delivery mechanism to the $24 billion newspaper and news magazine market which is both more cost-effective than centralized printing and distribution, and allows more fine-grained targeting of advertising.

The simplest form of news personalization involves selecting a news publication and choosing which daily and weekly sections to receive. The simplest form of advertising personalization is tuned to the demographics associated with the subscriber's ZIP or ZIP+4 code. Even with these entry-level forms of personalization, the Netpage Network offers a compelling distribution model for news.

Users receive paper publications with the usability of their traditional counterparts, but with interactive properties. At the press of an on-page button, a user can print an article giving the background to a news story, print a personalized product brochure, or add a product to the virtual shopping basket.

Any magazine normally printed on lightweight paper stock is equally well-suited to distribution on the Netpage Network. However, since Netpage Printers don't carry heavier paper stocks and don't provide wrap-around binding, the Netpage Network is less well-suited to the distribution of so-called "glossy" magazines.

9.1.2   Freelance Columns and Bulletin Boards

Users can choose to subscribe to individual freelance columns, cartoons, etc. These can be integrated into a user's daily news document, or printed individually. Freelancers can choose to receive micro-payments from their subscribers, freeing them from maintaining their own subscriber databases. The Netpage Network provides mechanisms for handling micro-payments.

Users can also subscribe to the "bulletin boards" of friends: collections of news, announcements, pictures etc., which work much like freelance columns.

9.2   ON-DEMAND PUBLICATIONS

The Netpage Network can deliver, on demand, current and back issues of periodicals normally delivered on subscription, including newspapers, magazines, and comics. To maintain the interactivity of all Netpages ever printed, the Netpage Network keeps all published content online at all times. Unlike the Web, where hyperlinks become unreliable over time, content on the Netpage Network never expires.

9.2.1   Flyers and Product Brochures

The Netpage Network makes high-quality flyers and product brochures instantly available, linked to advertisements and entries in printed catalogs.

Brochures are always up-to-date, and link to e-commerce, e-mail, and automatic telephone call-back. Brochure links can provide "click-through" fees to linking documents, and subsidized printing to users.

9.2.2   Books

Users can obtain the latest best-sellers or rare "out-of-print" (a soon-to-obsoleted term) editions on demand, printed in column format with a text size chosen by the user. A typical 300-page paperback fits on as little as 40 sheets of Letter paper. Slip-on covers are available for robust handling.

Titles which have outlived their copyright period are available for free. Other titles are heavily discounted for Netpage delivery, since publishers avoid the costs of printing, inventory storage, and delivery.

Colorful children's books reproduce immaculately. When they've been loved to death, they can be printed again, and again.

Children's coloring-in books and puzzles are available just when they're needed on a rainy day.

9.2.3   Television Infotainment

Users watching infotainment programs on television can print the associated informational material on their Netpage Printer by pressing the "print" button on their remote con-

trol at the appropriate time. The material may be a report on a new medical procedure, the plans for a do-it-yourself bookshelf, or a list of top investment opportunities. It may also be a subscription form for the publication the program is promoting.

The television and/or remote control is suitably modified or augmented to route the print request to the Netpage Printer.

9.3   E-COMMERCE

9.3.1   Online Purchases

The Netpage Network supports a similar level of online purchasing as the Web, but in paper-based medium which presents like a high-quality printed catalog.

A user can navigate the retailer's online Netpage catalog, printing catalog pages as they're needed and adding items to a virtual shopping trolley. The contents of the trolley can be listed at any time, and items can be struck from the list at the stroke of the pen. Pressing a "proceed to checkout" button at any time elicits a completed order form just waiting for the user's signature. The payment card account number is securely shown in the usual 1234 56** **** *789 format. The user's signature authorizes the payment.

9.3.2   Catalog Purchases

Rather than buying from an online Netpage catalog, the user can select items from a traditionally-printed catalog which contains active Netpage links.

9.3.3   Statements and Invoices

Statements and invoices can be securely and auditably delivered, and can be automatically filled in with the user's default payment details without the sender knowing those details.

The user's signature can authorize the payment as normal.

9.3.4   Secure Documents

Retailers can securely issue tickets and coupons over the Netpage Network, printed with difficult-to-forge watermarks.

Agencies of various kinds can issue licenses printed with watermarks and the user's own photograph.

As described earlier, recipients can verify the authenticity of secure documents using a standard Netpage Printer or a special verification pen.

9.3.5   Copyright Copying

Any printed version of a Netpage document becomes an easy means to printing another perfect copy. When a copy is made, the Netpage Network can automatically transfer a micro-payment from the copier to the copyright holder.

Trivial copyright fees are universally respected but seldom paid because of the inconvenience. The Netpage Network offers micro-payment convenience and the quality of an original copy.

9.4   COMMUNICATION

9.4.1   Mail

The Netpage Network, once widely subscribed, can be used to deliver numerous instances of regular mail-outs, particularly statements and invoices as discussed in Section 9.3.3. Once again, the Netpage System only delivers mail from authorized sources.

The United States Postal Service delivers 107,000,000,000 pieces of First Class mail each year [86], a large number of which are regular in nature.

9.4.2   Greeting Cards

A user can select a greeting card from an online catalog, add a handwritten message, and dispatch it via the Netpage Network. Cards can be addressed to other Netpage users, and to normal postal addresses. In the latter case the card is printed at the service center closest to the recipient, automatically placed in an envelope, and mailed through the local mail system.

Netpage users can choose to receive cards from anyone, or only from authorized friends.

9.4.3   Forms

Forms of all kinds can be printed on the Netpage Printer, filled in by hand, and submitted directly over the Netpage Network. Submission is secure and cannot be repudiated.

Handwriting is automatically recognized by the system. The digital ink of the handwriting is attached to the form in case a human clerk needs to re-interpret the handwriting. Automatic "handwriting bots" on the network can assist with the recognition task, automatically giving the user semi-intelligent feedback to elicit disambiguation.

Any interactive Netpage "application", including e-commerce and e-mail, uses forms of various kinds.

9.4.4   E-Mail

E-mail forms can be printed on demand and filled in by hand. The handwritten address is converted to facilitate delivery, but the rest of the message is delivered as digital ink, just as the user intended. If the recipient is computer-based rather than Netpage-based, all of the handwriting can be automatically converted, with the digital ink sent as an attachment, since it may contain hand-drawn diagrams etc.

Netpage users can choose to receive e-mail from anyone, or only from authorized friends.

9.4.5   Facsimile

Facsimile forms can be printed on demand and filled in by hand. The handwritten telephone number is converted to facilitate delivery, but the rest of the message is delivered as bitmapped digital ink, just as the user intended.

9.5   CORPORATE AND GOVERNMENT

9.5.1   Corporate Intranets

An organization can use a private intranet-based Netpage Network to implement a document repository and efficiently distribute documents on demand.

9.5.2   Government Services

Government can provide access to services via the Netpage Network. The network can obviate the need to visit government offices to obtain forms and submit forms, and the network can be used to efficiently deliver the results of submissions.

9.6   PERSONAL

9.6.1   Web Browsing, Searching and Printing

Users can browse the World Wide Web via their Netpage Printer using paper and pen as the user interface. Netpage forms can provide emulation of HTML forms. Only dynamic media objects may fail to print meaningfully.

A Netpage Printer can be the ideal output device for documents encountered while browsing the Web, whether the browsing is terminal-based or Netpage-based. An increasing number of print-ready documents are being published on the Web.

Entire Web sites can be compactly formatted for print, since a printed page has a much greater information-bearing capacity than a computer screen, and perused in a more leisurely fashion. The Netpage Formatting Server automatically adds a table of contents and an index of referenced pags.

Links on Web pages remain active when printed on Netpages. Clicking on a link causes the linked Web page to be printed.

Web pages and search results are printed on both sides of the paper, allowing one sheet of paper to hold the equivalent of ten SVGA screens of information. Thus the user sees 200 links on paper, compared with only 20 on a computer screen.

9.6.2   Photo Album

A Netpage Printer can be enhanced with an infrared data connection (IrDA) to allow it to accept images wirelessly from a digital camera. Alternatively, digital cameras with USB ports can be directly connected. Images can be automatically archived on the Netpage Network, and individual photos, both regular and poster-sized, can be printed at photo quality on the printer.

Smart layout software can assist with the interactive creation of photo album pages, ready for insertion in a cumulative family album.

9.6.3   Notebook

A pre-printed Netpage notebook can be used to capture handwritten notes in a persistent fashion. Notes are captured on the network and are optionally timestamped and signed by a certificate authority to provide undeniable proof of priority, for example with respect to

a patent application. Since the handwriting is recognized and converted to text for indexing purposes, the notes can also be searched by keyword, date, etc.

9.6.4 Examination Papers

Students can sit exams in a controlled manner while physically distant from the classroom.

An examination paper can be delivered at a specific time to a distributed collection of students. The students can then be required to answer the questions on the paper within the alloted time. Their answers can be automatically captured at the end of the allotted time using the "blackboard" form model, and in many cases automatically graded. Once again, unrecognized input can be routed to a human operator.

9.6.5 Computer Printing

A Netpage Printer can be the ideal output device for a personal computer or workstation, whether directly-connected or on a local-area network. The speed of the Netpage Printer and the quality of its output make it attractive to existing computer users.

The Netpage Printers have a USB port as a standard feature.

10 Business Models

10.1 SYSTEM PRINCIPLES

The Netpage Network leverages the open technology and extensive infrastructure of the Internet. The widespread acceptance and growth of the Netpage Network is predicated on open competition rather than monopolistic practices.

However, to provide an incentive to early investors, semi-exclusive licenses to Mem-jet-based Netpage Printer designs will be offered, as well as licenses to manufacture paper and ink consumables.
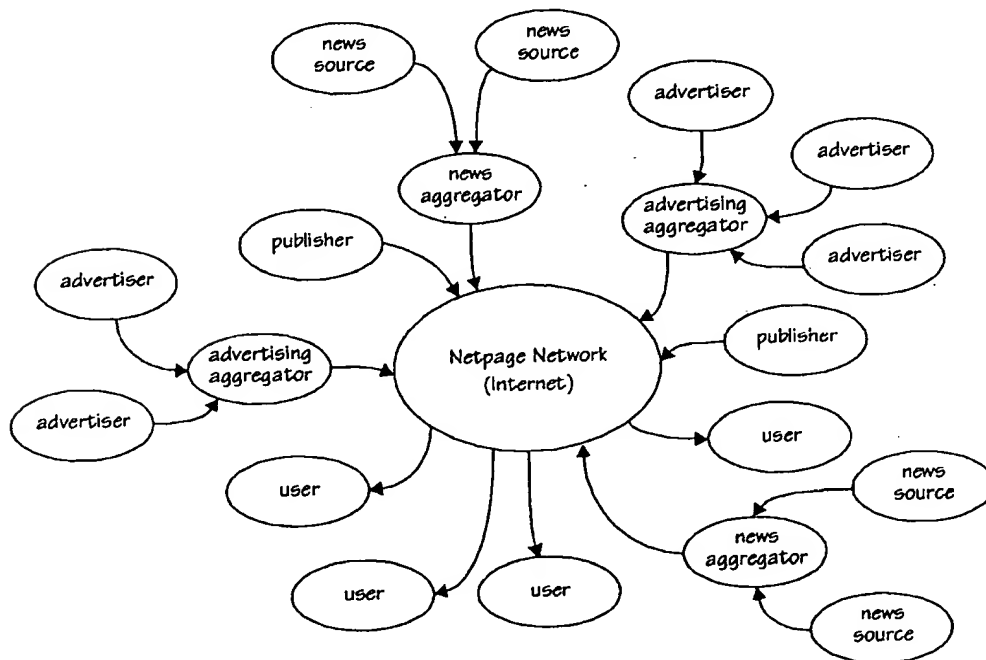
Figure 5. Open structure of Internet-based Netpage Network

The network supports any number of independent participants, some of which have complementary roles, and some of which compete. The open structure of the network is illustrated in Figure 5. Content-related participants include the following:

- news sources
- publishers
- news aggregators
- freelance artists, writers, cartoonists
- direct mailers
- advertisers
- advertising aggregators
- banks
- merchants

Infrastructure-related participants include the following:

- server suppliers
- network storage providers
- communications carriers
- Internet service providers (ISPs)
- printer dealers
- printer installation and servicing companies
- ink and paper consumables dealers
- consumables delivery companies

Technology-related participants include the following:

- research and development
- chip makers (printheads, controllers, QA)
- printer manufacturers
- ink and paper consumables manufacturers

The strength of the network lies in the fact that publication and delivery are completely decoupled. This allows the delivery infrastructure to grow independently of the participation of publishers.

10.2   BOOTSTRAPPING

Because consumers are unlikely to be motivated to acquire a Netpage Printer until a variety of publications and services are available, and because publishers will wait for an installed base before participating, the key to bootstrapping the network is to bundle the printer with a publication or service subscription, and possibly trimming profit margins in the growth stage.

There are several ways the manufacturing cost of the Netpage Printer, assumed to be well below $100, can be subsidized. Printer-based distribution can eliminate existing distribution costs, offsetting the printer cost. The printer can provide a new mechanism for delivering advertising, with advertising profits offsetting the printer cost. And the printer cost can be built into the subscription fee for a publication or service.

The cost of printing and delivering a newspaper normally exceeds the price of subscription [34,66]. The real profit lies in the advertising. The cost of the Netpage Printer is easily exceeded by one years' cost savings, allowing a Netpage subscription, including a "free" printer, to be priced lower than a traditional subscription. A Netpage subscription offered to a customer already on the network would be priced correspondingly lower still.

If the publication or service delivered via the Netpage Printer is sufficiently lucrative, then the publisher or provider may be able to subsidize not only the printer itself, but also its running costs. This can include Internet access, paper and ink consumables, and servicing. Demographics-informed advertising may fall into this category. The more information customers reveal about themselves, the greater the value of the advertising to the advertisers, and so the greater the level of subsidization that can take place.

Early investors who subsidize the installation of Netpage Printers may be able to recover the investment and turn a profit merely by charging other publishers an access fee to the

printers they "own", perhaps for an interim period after installation, according to a network-wide agreement. They may also be able to earn commissions on click-throughs and e-commerce transactions originating on pages printed on "their" printers.

Similar approaches are already emerging in the general Internet market. In the "FreePC" and related models [49], personal computers are bundled with Internet access, and the whole package is fully or partially subsidized by advertising and e-commerce.

Most content-related participants in the Netpage Network, and even Internet service providers, can benefit from directly investing in Netpage Printer deployment.

10.3   MATURITY

Many of the bundling approaches are likely to remain applicable once the network becomes widely subscribed. It is possible that the bundling of the appliance (i.e. the Netpage Printer) with the service (be it Internet access or a publication subscription) will remain the dominant means of distributing the appliance, as it is in the cellular telephone market, and as an increasing number of companies, including IBM [23], are beginning to believe it should be in the personal computer market.

10.3.1   News Publishers and News Aggregators

News publishers with strong brands are likely to be able leverage those brands on the Netpage Network. They have an incentive to do so quickly to prevent newcomers from filling the vacuum and capturing the attendant advertising revenue.

News publishers also have an incentive to migrate to the Netpage Network because it allows them to offer the more fine-grained targeting that advertisers are increasingly demanding, and which they are increasingly seeking elsewhere.

News publishers who create content rather than simply aggregating other sources have a significant advantage, since they offer both unique content and an editorial voice. Users are more likely to choose a single news publication whose content and editorial orientation they find useful, than specifying to a news aggregator how to glue together a number of disparate news sources. And any sufficiently strong news publication brand is unlikely to make its content available to an aggregator, since the aggregator will be taking a proportion of advertising and e-commerce revenue.

The Netpage Network, like the Web, offers lower barriers to entry than traditional publishing media, and this naturally stimulates greater diversity. However, the geographic independence of the network, coupled with built-in mechanisms for localization of publications, allows international, national and regional news publications to more easily compete in local news markets.

The strength of a traditional local news publication lies partly in its local news content and partly in its local retail advertising and classified advertising content. Aggregation of classified advertising is already happening on the Web, and the Netpage Network will make the same thing possible for local retail advertising. Local news publications are therefore likely to be excluded from the direct capture of local advertising, and may instead transform themselves into news gatherers feeding localized editions of larger publications.

10.3.2   Advertising Aggregators

The Netpage Network promises to be the most effective advertising medium ever conceived. It combines the editorial and print quality of traditional publications with arbitrarily finely targeted advertising, and provides a direct link between advertising, product information, and purchasing.

Because personalization and localization are handled automatically by Netpage Publication Servers, an advertising aggregator can provide arbitrarily broad coverage of both geography and demographics. The subsequent disaggregation is efficient because it is automatic.

This makes it more cost-effective for publishers to deal with advertising aggregators than to directly capture advertising. Even though the advertising aggregator is taking a proportion of advertising revenue, publishers may find the change profit-neutral because of the greater efficiency of aggregation.

Because of the finer targeting supported by the Netpage Network, publishers and advertising aggregators have a larger advertising space to sell, leading to greater profits. The linking between advertising, detailed product information, and purchasing, and the corresponding measurability of consumer behavior, leads to greater profits from click-through fees and e-commerce commissions, benefiting publishers and advertising aggregators alike.

Added revenue from these fees and commissions may even allow users' costs - printer, ink, paper, and Internet access - to be fully subsidized.

NETPAGE PRINTER

11 Printer Product Design

Netpage Printers are intended for use in domestic, commercial, corporate and hospitality environments. They are all based on a simple and reliable straight paper path, passing through a Memjet transfer roller printhead mechanism. In most cases the printed page is glued along one edge and adhered to the previous page to form a final bound document that can be 1 page or 500 pages thick. They all interact with the wireless Netpage Pen.

Netpage Printers come in various forms: wall-mounting, tabletop, portable, and pocket versions.

11.1 WALLPRINTER

A low-cost, wall-mounted, base model with a duplex 8½" Memjet printhead array that accepts a full ream of US Letter paper in a vertical format as shown in Figures 6, 8 and 9. Paper is placed into a hinged top tray down onto a sprung platen and registered under edge guides before being closed. Figure 7 shows the access to the paper and ink cartridge.

A replaceable cartridge containing cyan, magenta, yellow, and infrared inks and glue is also accessible when the tray is open. It connects via a series of self-sealing connectors to hoses that transmit ink and glue to their separate locations. The cartridge consists of a thin wall drawn aluminum casing that accommodates four ink bladders and a single glue bladder into an injection molded connector base. This is a fully recyclable product with a capacity for printing and gluing 3000 pages (1500 sheets). It is protected from forgeries by use of an authentication chip [1,2].

When closed, a release mechanism allows the platen to push the paper against the pick-up roller assembly, where it is fed directly into the duplex Memjet printhead assembly. From there, the sheet passes a momentary action glue wheel with powered spike wheels, where it has glue applied to the vertical edge as it passes through. The glue wheel is capped when not in use and is operated by a powered camshaft.

The printed sheet is fed down to a binding platen that operates with a closed steel wire loop system of pulleys, runners and a powered axle. This provides the necessary speed to push the sheet forward onto the rear of a previous sheet, glue/bind it and return to the home position to accept the next printed sheet in less than 2 seconds. A motorized paper tapper assembly aligns the sheets in a simultaneous operation.

When a document is bound and finished, a powered exit hatch with a tamper sensor opens. Plastic foils work together with the hatch to direct the finished document to the back of the collection tray and feed any further documents into the tray without hitting existing ones. The collection tray is molded in clear polycarbonate and pulls out of its socket under a certain loading. Access for removing documents is provided on three sides.

The printer has a main PCB that accommodates all major circuitry components including external data jacks. A flex PCB runs from the main PCB to the paper tray and has three different color LEDs and a push button. The LEDs indicate "on", "ink out", "paper out", and "error". The push button is a "help" interface that prints out a simple instruction sheet and a compact features directory for the user. The unit is powered by an internal 110V/220V power supply that is connected before wall-mounting.
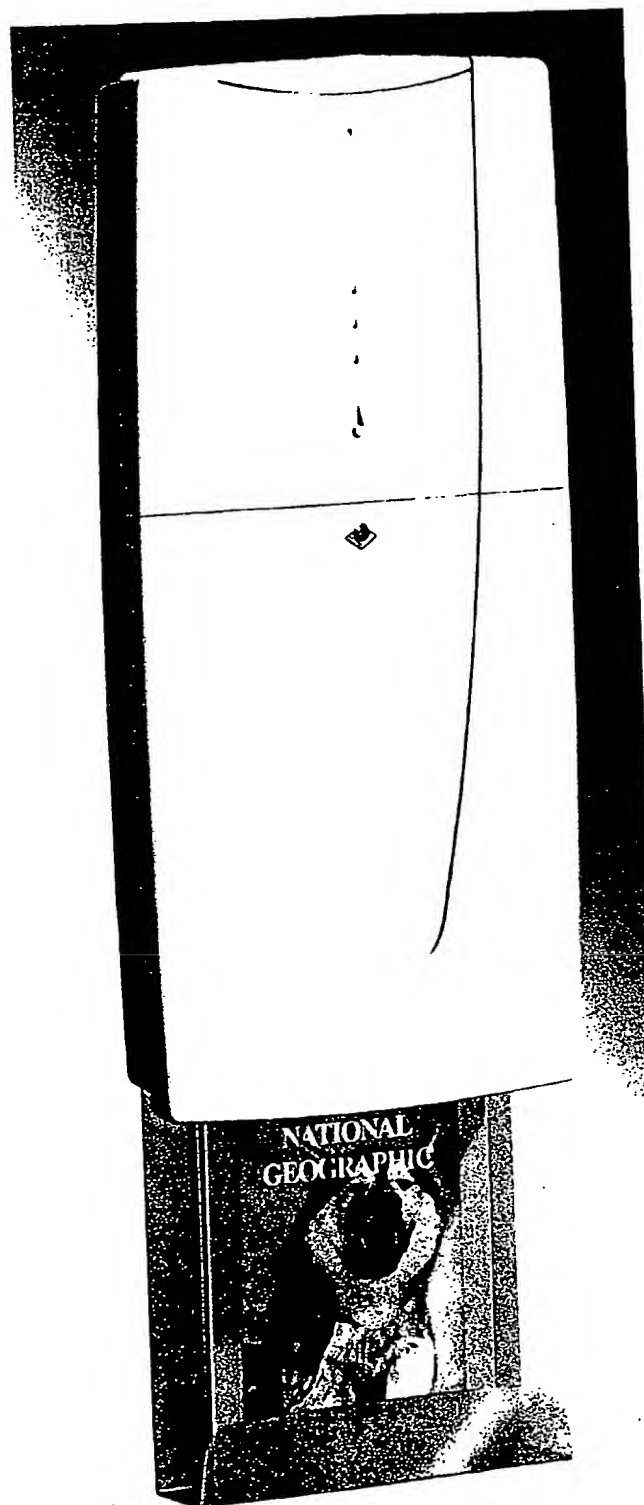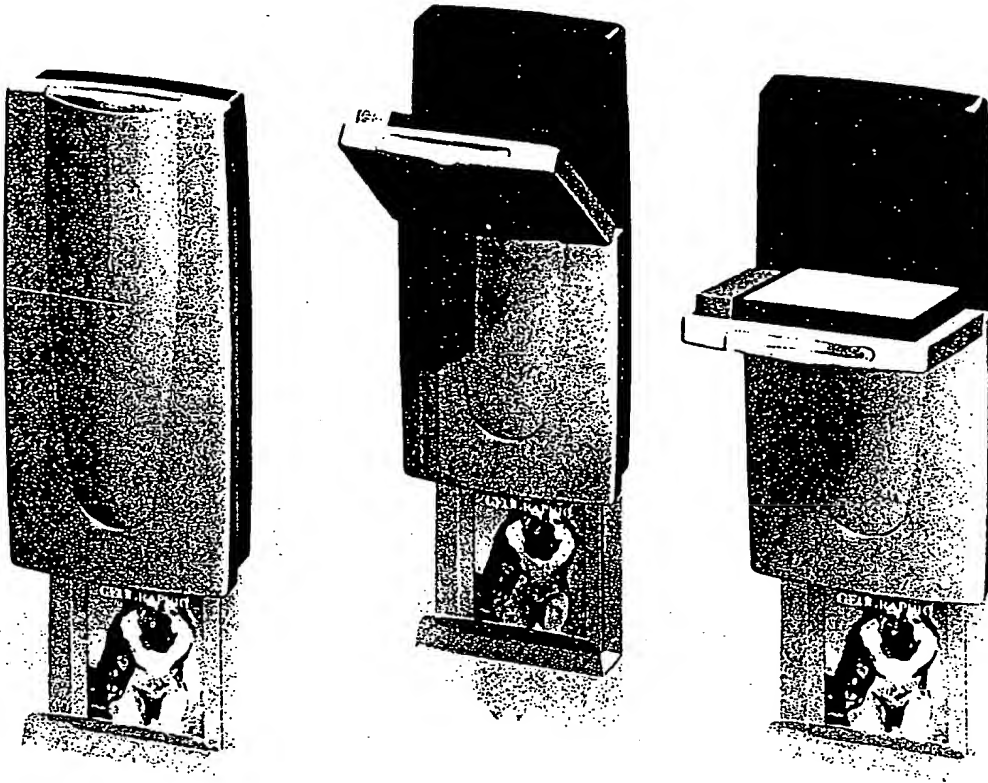
Figure 6. Wallprinter

Figure 7. Wallprinter paper and ink cartridge access

The printer has several metal hangers on the rear, which locate into keyhole slots in a metal back plate that is securely fastened to a wall. When the printer has been connected, it is hung onto the back plate and fixed with a locking screw found under the paper tray.

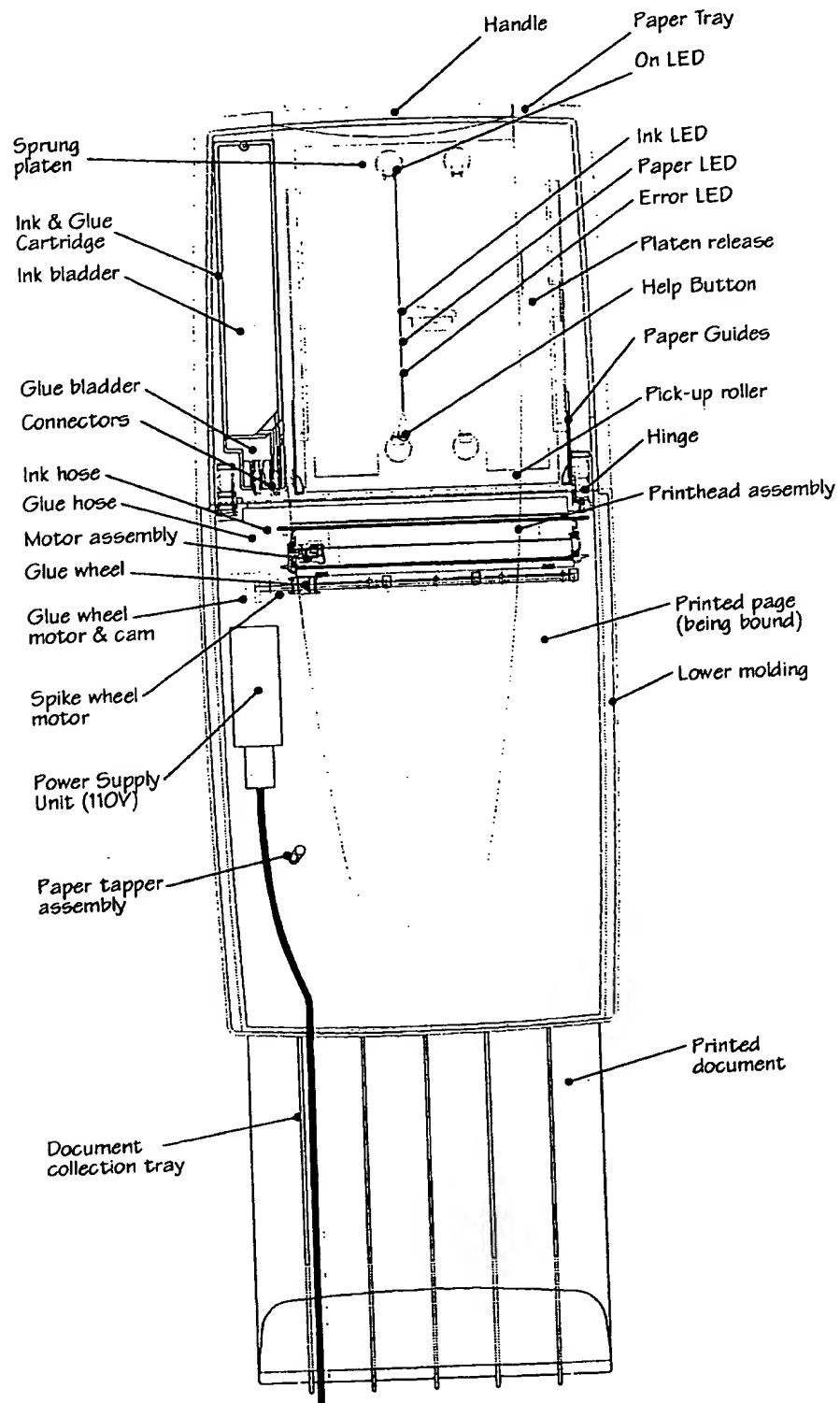The Netpage Printers are fully customizable in finishes and color as the front moldings clip on to a core chassis and are easily removable.

Handle Paper Tray
On LED

Sprung
platen
Ink LED
Paper LED
Error LED

Ink & Glue
Cartridge
Ink bladder
Platen release

Help Button

Paper Guides

Glue bladder
Connectors
Pick-up roller

Hinge

Ink hose
Glue hose
Printhead assembly
Motor assembly
Glue wheel

Glue wheel
motor & cam
Printed page
(being bound)

Spike wheel
motor
Lower molding

Power Supply
Unit (110V)

Paper tapper
assembly

Printed
document

Document
collection tray

Figure 8. Wallprinter front elevation

Paper tray molding

Handle

Chassis molding

Cover molding (clip-on)

Backplate (metal)

Locking screw

Platen release

Hangers

Paper

PCB

Paper guide

Hinge

Data connector

Pick-up roller assembly

Printhead assembly

Glue wheel

Spike wheels

Glue wheel motor & cam

Platen runners

Steel wire loop

Power Supply Unit (110V)

Platen motor & drum

Printed pages (being bound)

Binding platen

Pulleys

Paper tapper assembly

Foils

Exit Hatch

Printed document

Document collection tray

Figure 9. Wallprinter side elevation

11.2 WALLPRINTER PRO

This printer is similar to Wallprinter in most respects, except that it has a duplex 11" print-head assembly, which prints on US Letter paper in a landscape format (see Figures 10, 11 and 12). This means a faster print time and binding time for each page, making for faster overall document delivery.

Another difference is the location of the ink cartridge, which resides above the paper tray rather than down the side. Each page is glued along the horizontal edge by a full-length glue sponge, which is capped when not in use. Operation, printing, and document handling are identical to Wallprinter.

Wallprinter Pro is fully customizable in finishes and color.
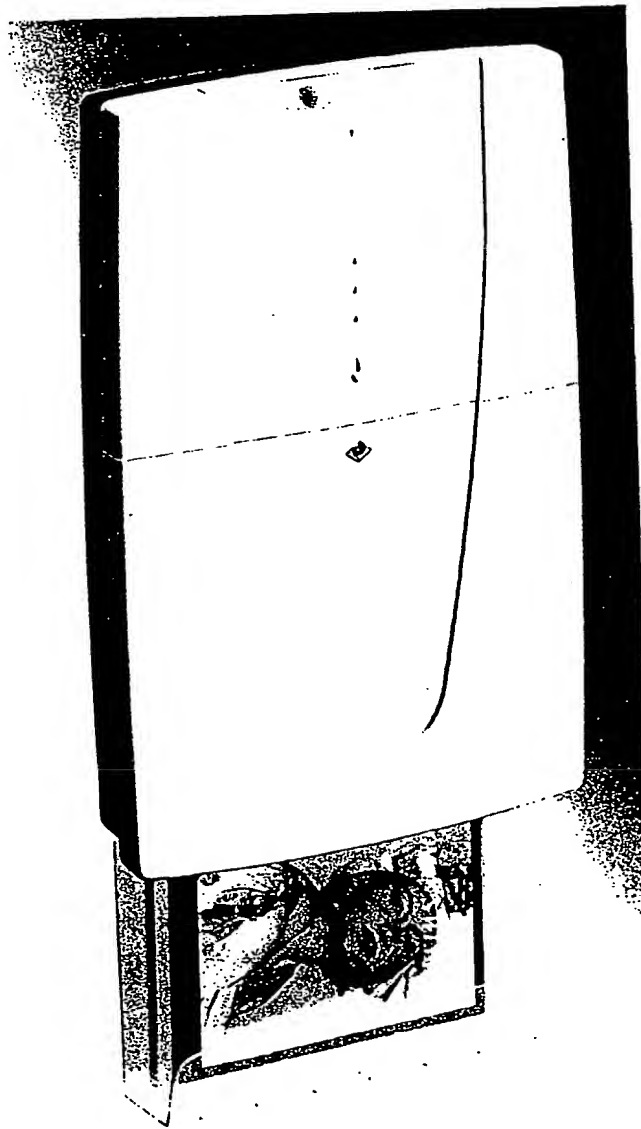
Figure 10. Wallprinter Pro

Ink & Glue
Cartridge

Ink bladder

Handle

On LED

Paper Tray

Glue bladder

Connectors

Ink LED

Paper LED

Error LED

Sprung
platen

Platen release

Help Button

Paper Guides

Pick-up roller

Motor assembly

Hinge

Ink hose

Glue hose

Printhead
assembly

Glue strip

Glue strip
motor & cam

Printed page
(being bound)

Spike wheel
motor

Lower molding

Paper tapper
assembly

PowerSupply
Unit (110V)

Printed
document

Document
collection tray

Figure 11. Wallprinter Pro front elevation
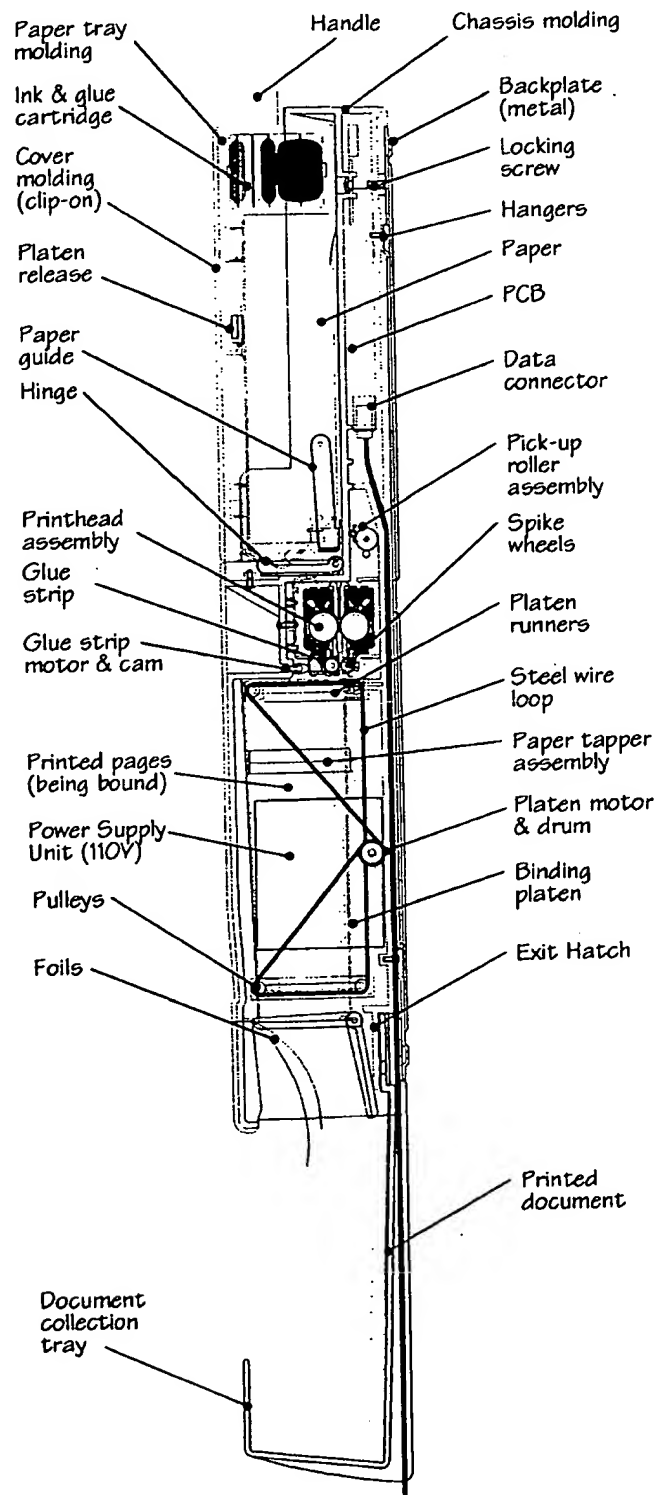
Figure 12. Wallprinter Pro side elevation

11.3   TABLEPRINTER PRO

This printer is a tabletop version of the Wallprinter Pro. Essentially, it is the same printer unit with a base plinth that adds extra functionality, such as USB, parallel port and a power socket (see Figure 13).

Tableprinter Pro is fully customizable in finishes and color.
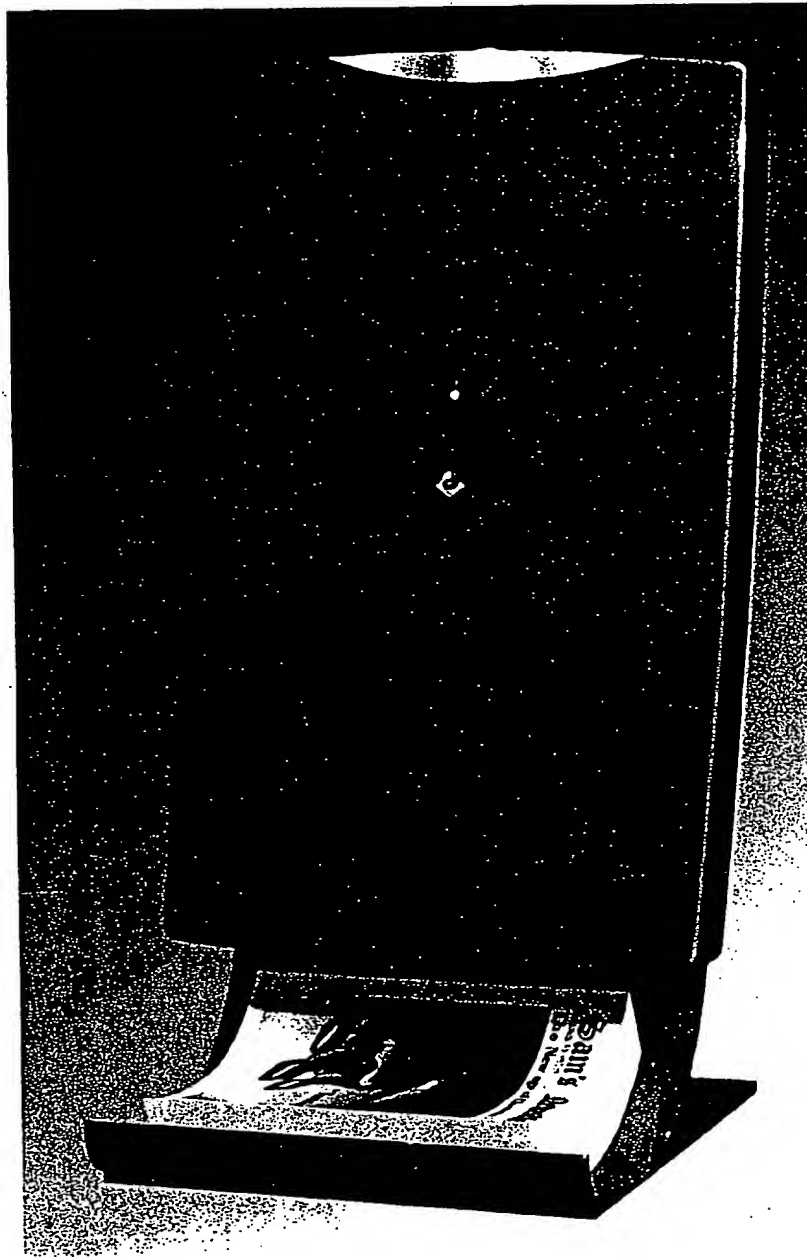
Figure 13. Tableprinter Pro

11.4   WALLPRINTER PRO R

This printer shares the same printing and binding configuration of US Letter landscape format as Wallprinter Pro. The main difference is the media delivery, which is in the form of a large print cartridge cartridge (see Figures 14, 15 and 16). This cartridge accommodates C, M, Y, and infrared inks and glue as well as a 1000 sheet capacity roll of paper. The cartridge can be recharged at nominated outlets when required and it is protected from forgeries by an authentication chip [1,2].

The printer has integral structural metalwork to support its weight and a ball bearing track for easy loading and removal.

Wallprinter Pro R is fully customizable in finishes and color.
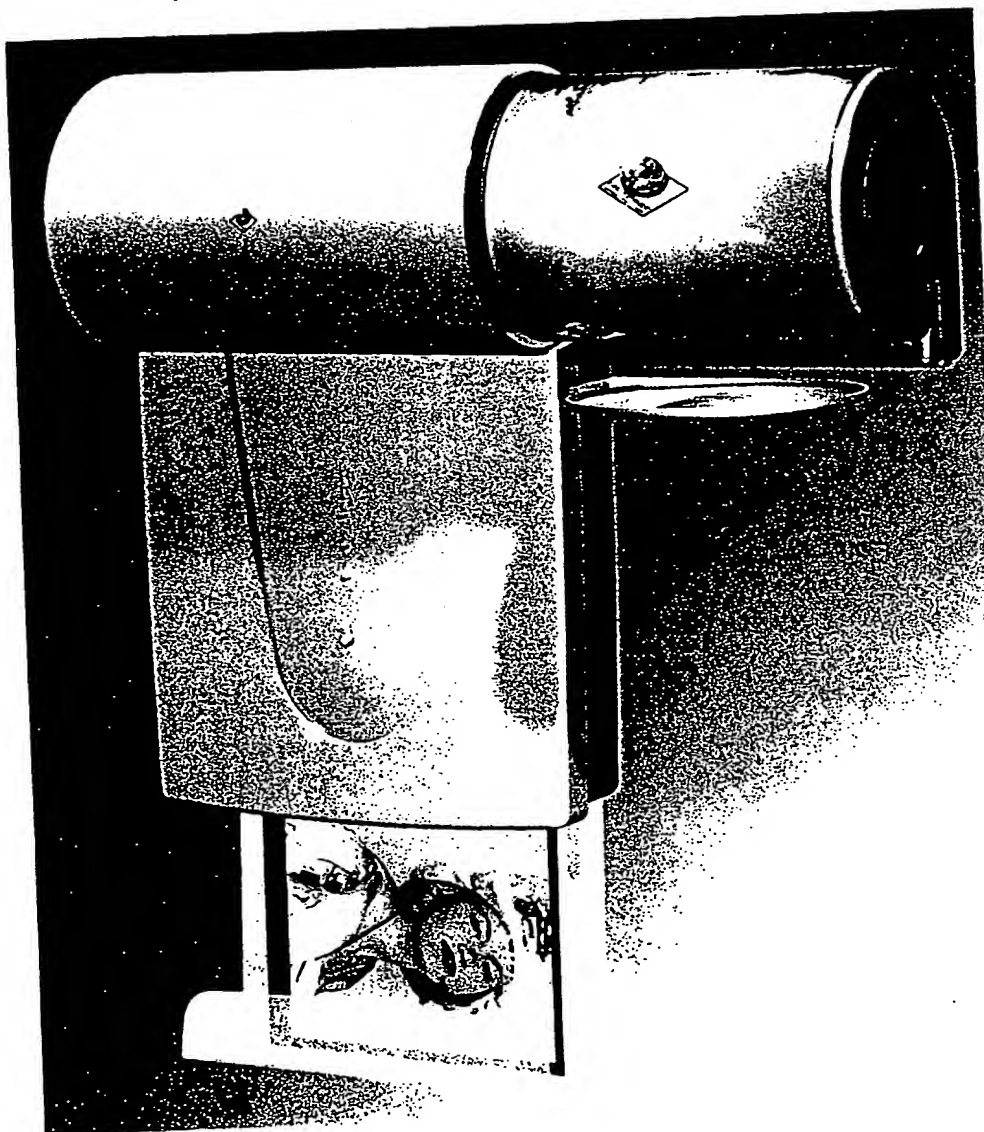
Figure 14. Wallprinter Pro R, with print cartridge extracted

Roll drive & ink connector area

Hatch

Print roll

Ink hose
Glue hose
Motor assembly
Glue strip
Glue strip motor & cam
Spike wheel motor

On LED

Printhead assembly

Ink LED
Paper LED
Error LED

Help Button

Power Supply Unit (110V)

Printed page (being bound)

Lower molding

Paper tapper assembly

Printed document

Document collection tray
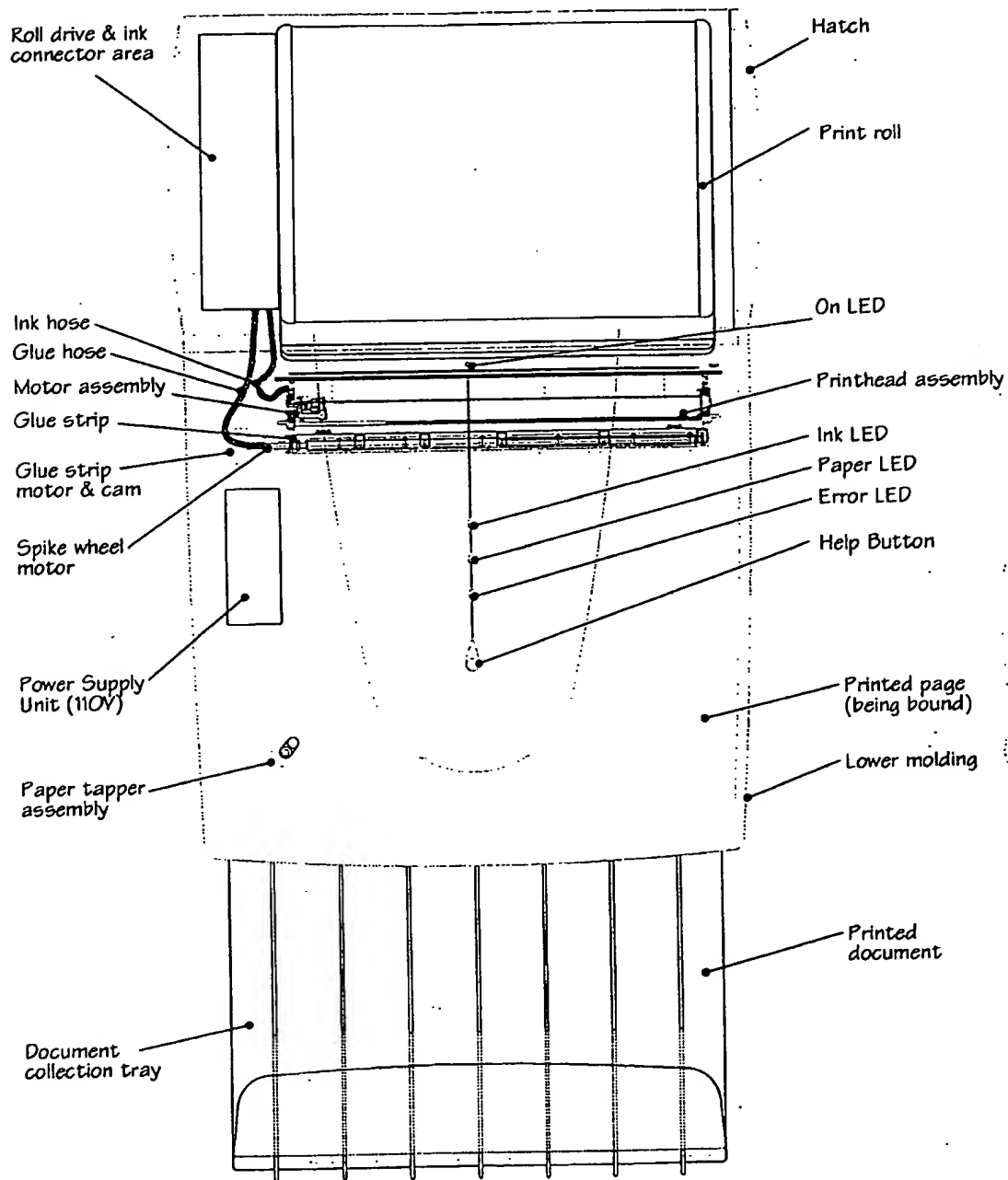
Figure 15. Wallprinter Pro R front elevation
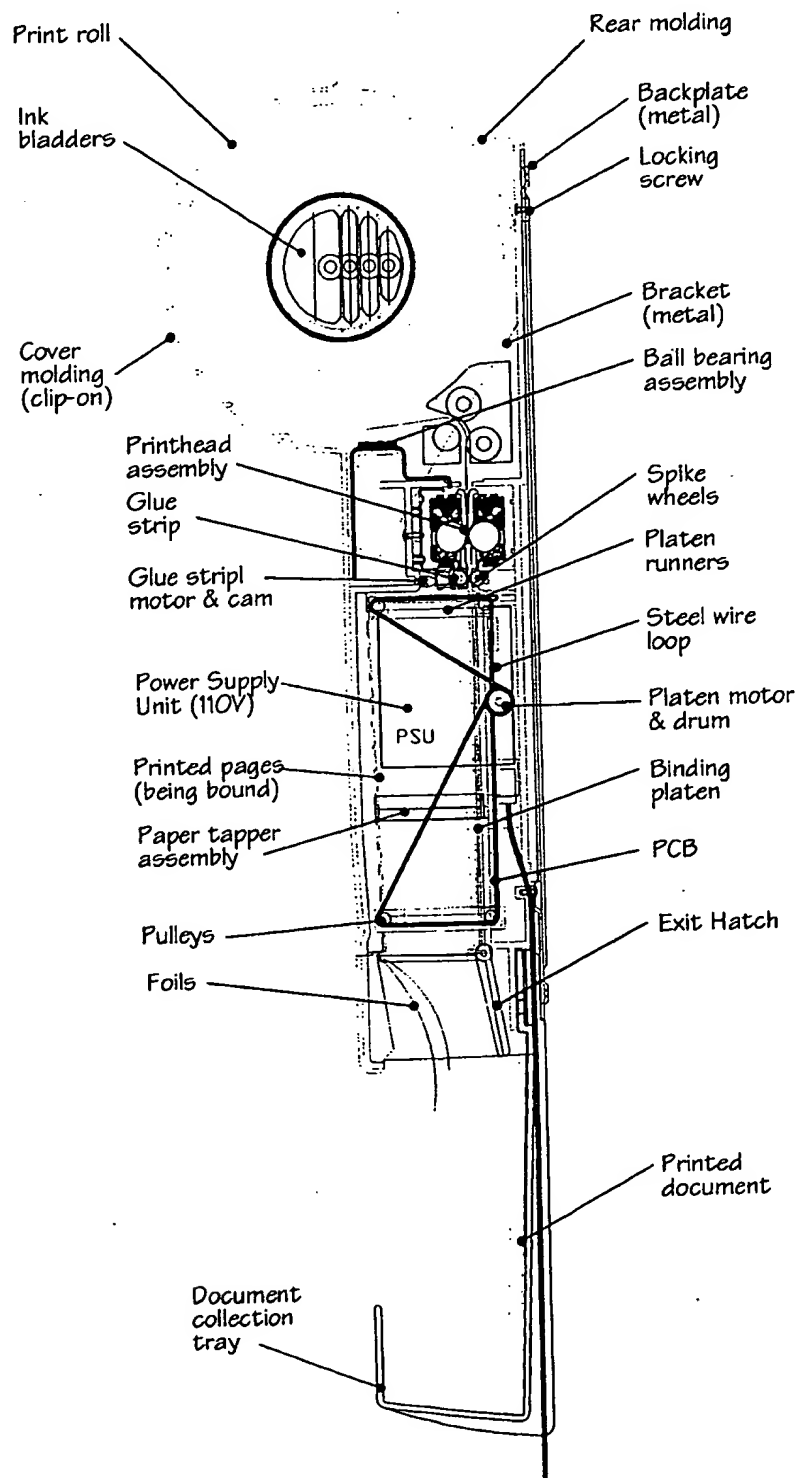
Figure 16. Wallprinter Pro R side elevation

11.5   TABLEPRINTER PRO R

This printer is a tabletop version of the Wallprinter Pro R. Essentially, it is the same printer unit with a base plinth that adds extra functionality, such as USB, parallel port and a power socket (see Figure 17).

Tableprinter Pro R is fully customizable in finishes and color.
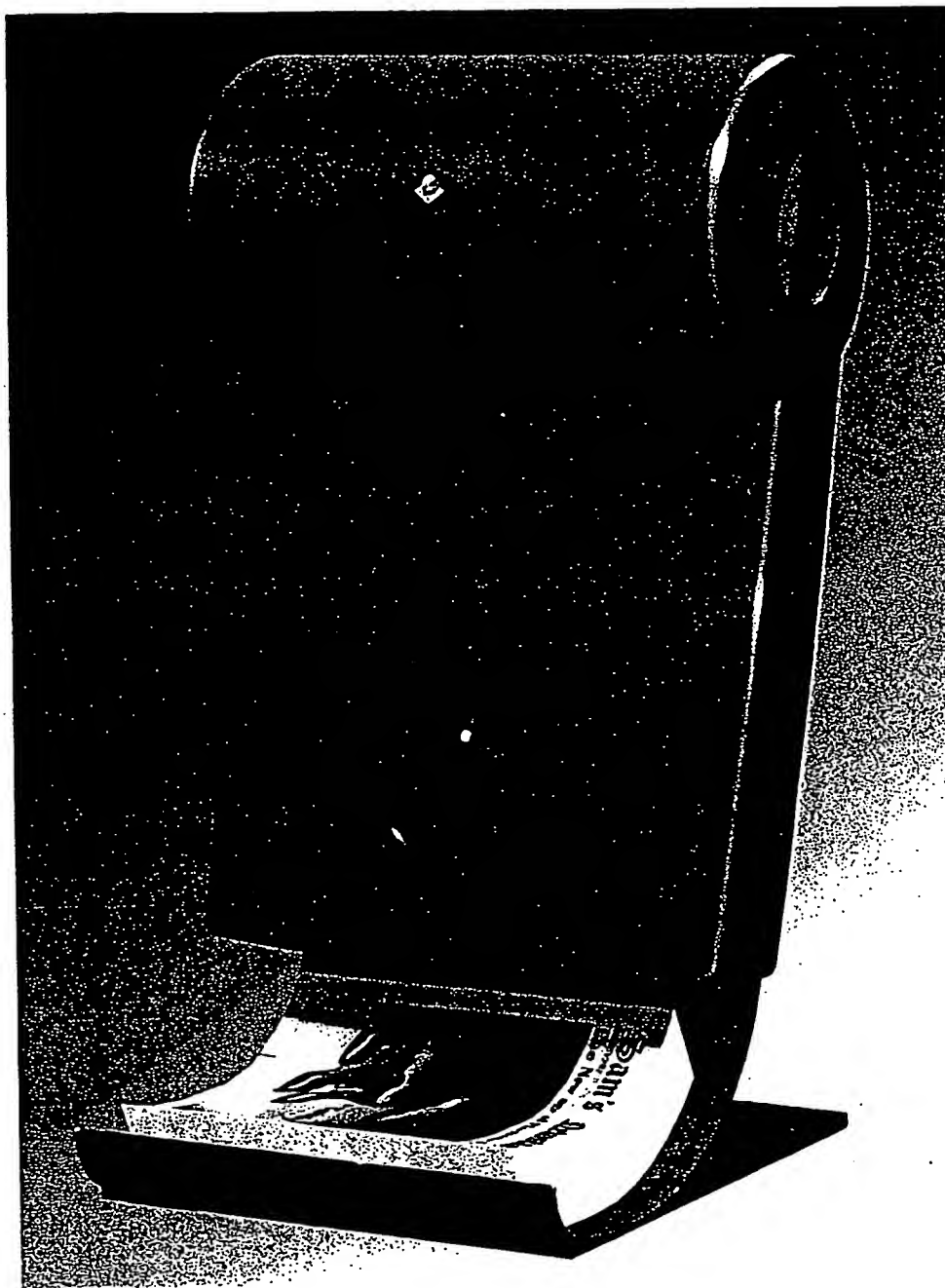
Figure 17. Tableprinter Pro R

11.6   DESKPRINTER PRO R

The Deskprinter Pro R is a vertical format printer based around the large format print cartridge (see Figures 18, 19, 20 and 21). This cartridge accommodates C, M, Y, Infrared inks and glue, as well as a 1000 page roll of paper. The print cartridge is lowered into the top of the unit through a latching hatch. When printing, the paper is fed through the printhead assembly where it is duplex printed and then ejected past a cutter which crops it into sheets. As the sheet passes the cutter, a glue wheel assembly glues along the long edge and powered spike rollers propel the sheet out into the binding area.

The binding area consists of a binding platen which operates with a closed steel wire loop system of pulleys, runners and a powered axle. This provides the necessary speed to push the glued sheet forward onto the rear of a previous sheet, glue/bind it and return to the home position to accept the next printed sheet in less than 2 seconds. A motorized paper tapper assembly aligns the sheets in a simultaneous operation.

When the document has been bound, a series of metal fingers at the top and bottom of the document rotate out of the way and the document is pushed into the out tray area. A powered hatch opens and a motorized ejector assembly pushes the document through the exit slot of the unit. The hatch then closes onto the document ready for removal. Subsequent documents are stacked up in a similar fashion. The user interface is identical to the other printers in the range. A large PCB contains all the processing and external interface components and connects to an internal 110V/220V power supply unit.

Deskprinter Pro R is fully customizable in finishes and color.
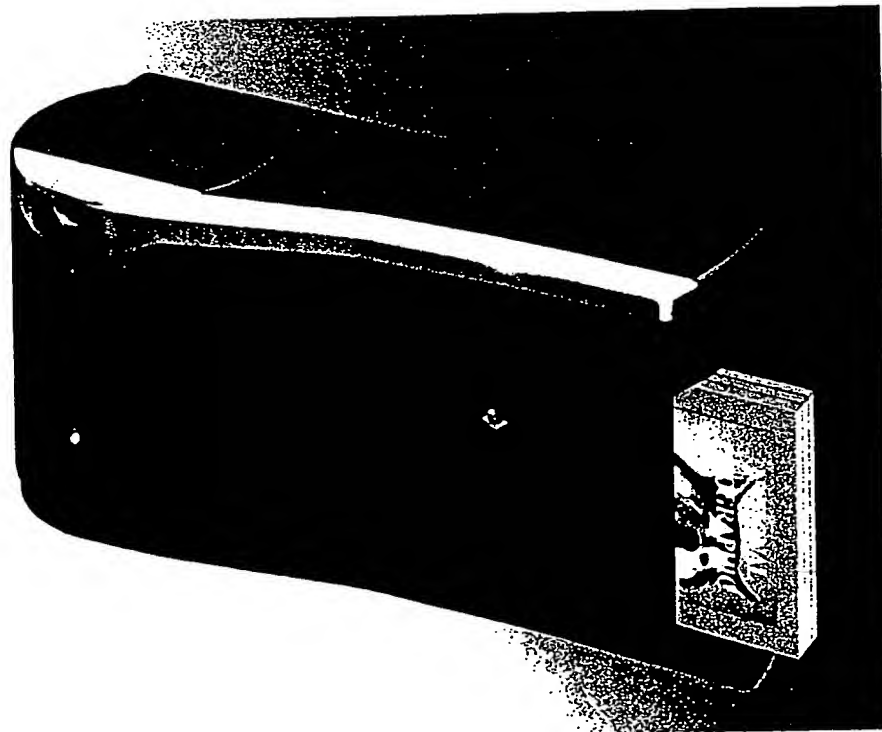
Figure 18. Deskprinter Pro R
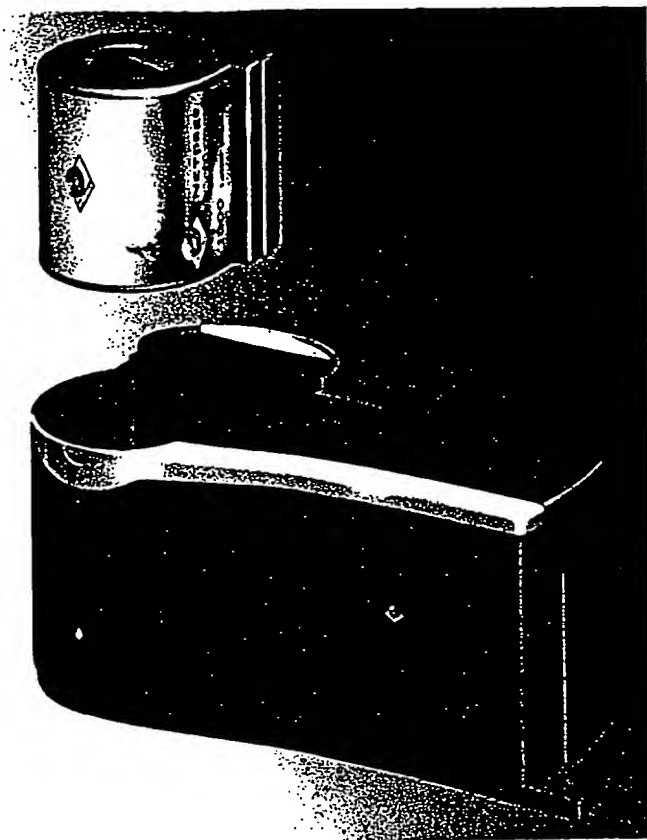
Figure 19. Deskprinter Pro R, with print cartridge extracted
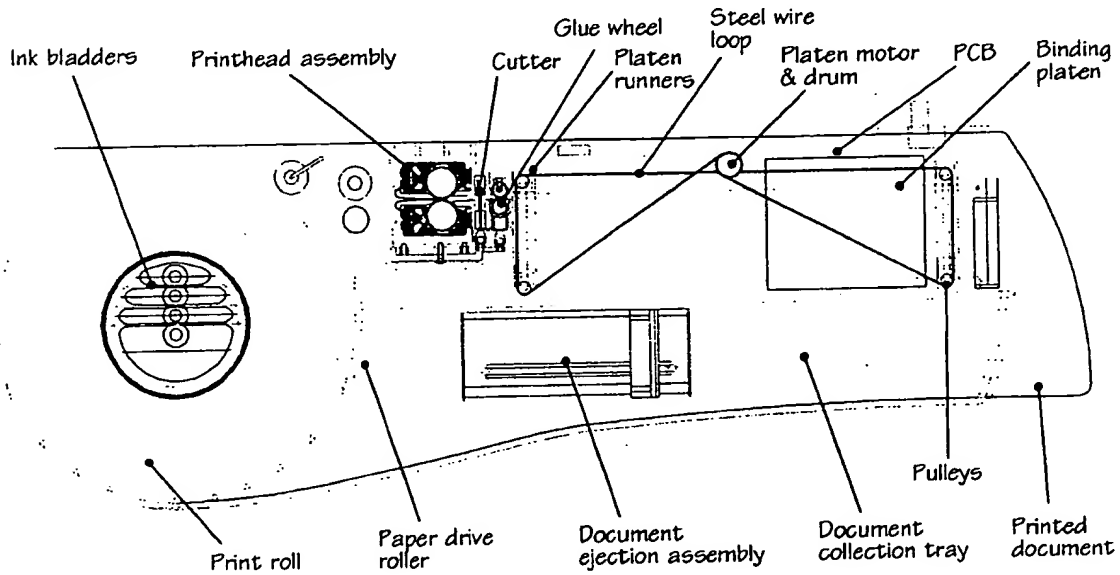
Figure 20. Deskprinter Pro R plan
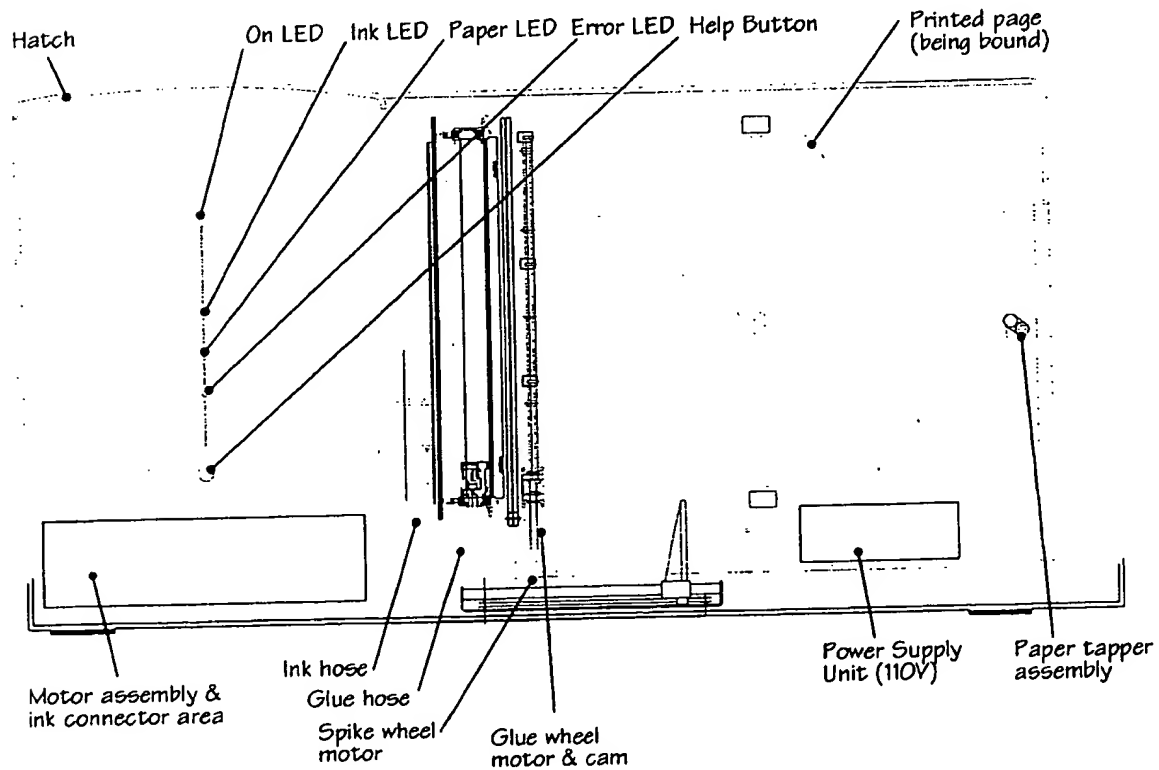
Figure 21. Deskprinter Pro R elevation

11.7   TRAVELPRINTER R

The Travelprinter R is a small, lightweight, versatile and completely portable Netpage Printer (see Figures 22, 24, 25 and 26). It has in-built mobile network communication hardware and software, allowing it to download documents anywhere. Travelprinter also has communications ports for computer interface printing when required.

The printer consists of a front and rear molding with a chassis to accommodate the major components including a lithium battery and an 8½" duplex Memjet printhead assembly.

A compact print cartridge cartridge with C, M, Y and infrared inks and paper is used in the printer, providing 50 US Letter pages or 100 A5 pages. It is protected from forgeries by an authentication chip.
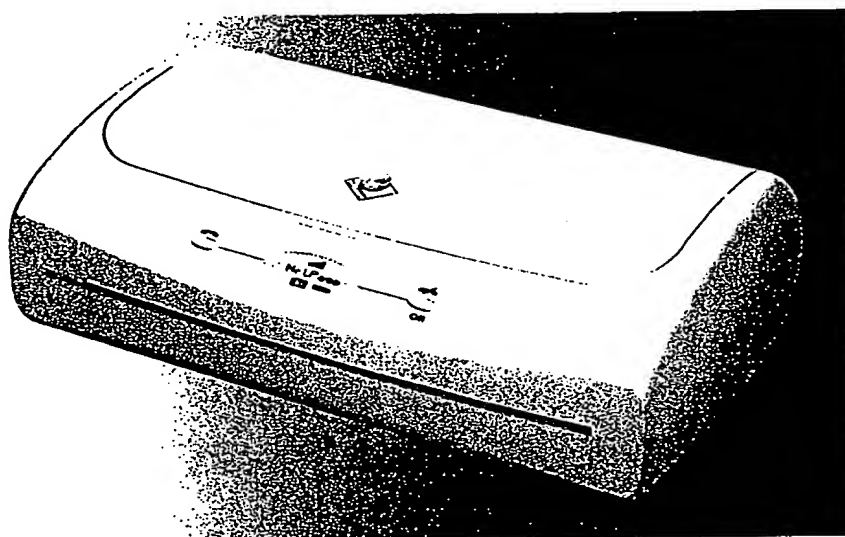
Figure 22. Travelprinter R

A motorized guillotine assembly cuts the media between the cartridge and the printhead and motorized spike wheels eject the finished print out of the unit. A flex PCB runs from the main board to a segment LCD and two push buttons. The LCD shows signal strength, any errors, battery and number of pages left in the cartridge. The buttons allow the printer to either connect to the Netpage Network or to act as a stand-alone printer. A USB interface is provided on the side of the printer along with DC 3V input.
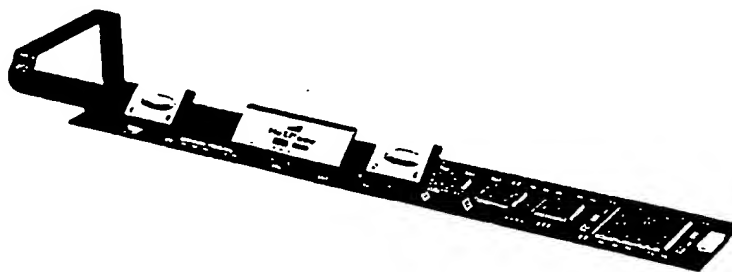
Figure 23. Travelprinter R main and flex PCB, with buttons and segment LCD
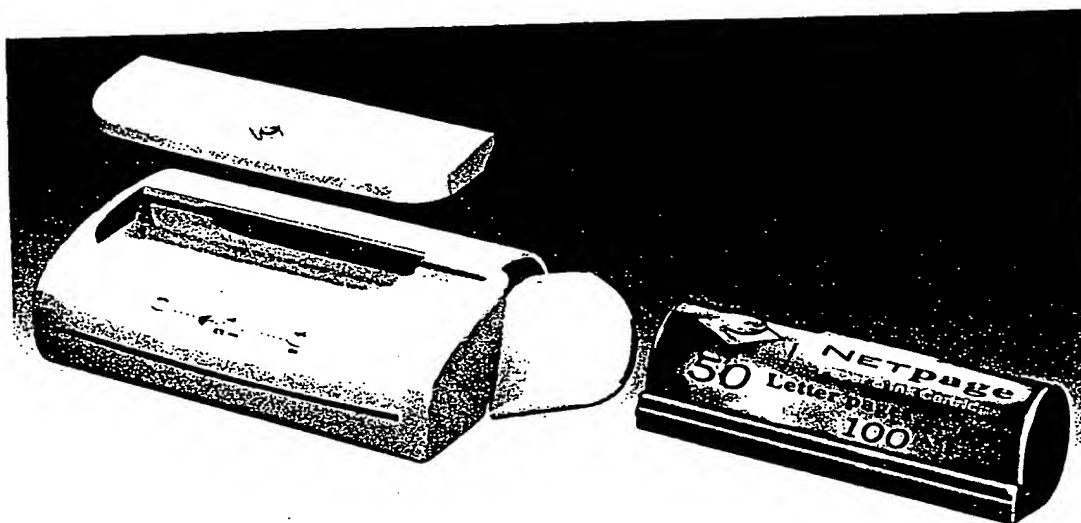
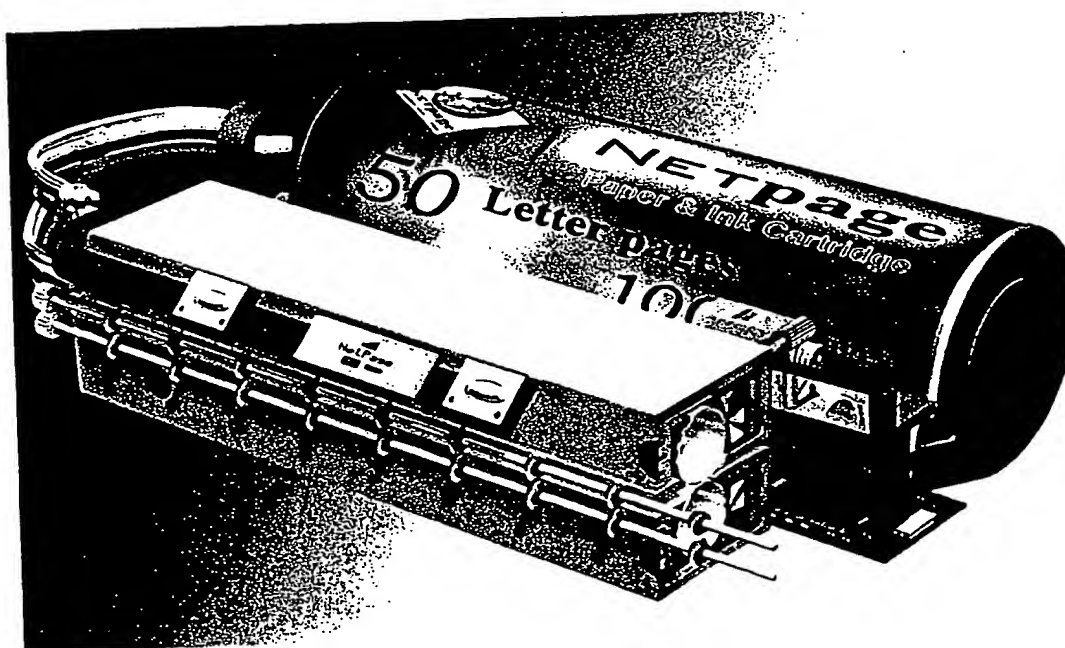Figure 24. Travelprinter R, with print cartridge extracted

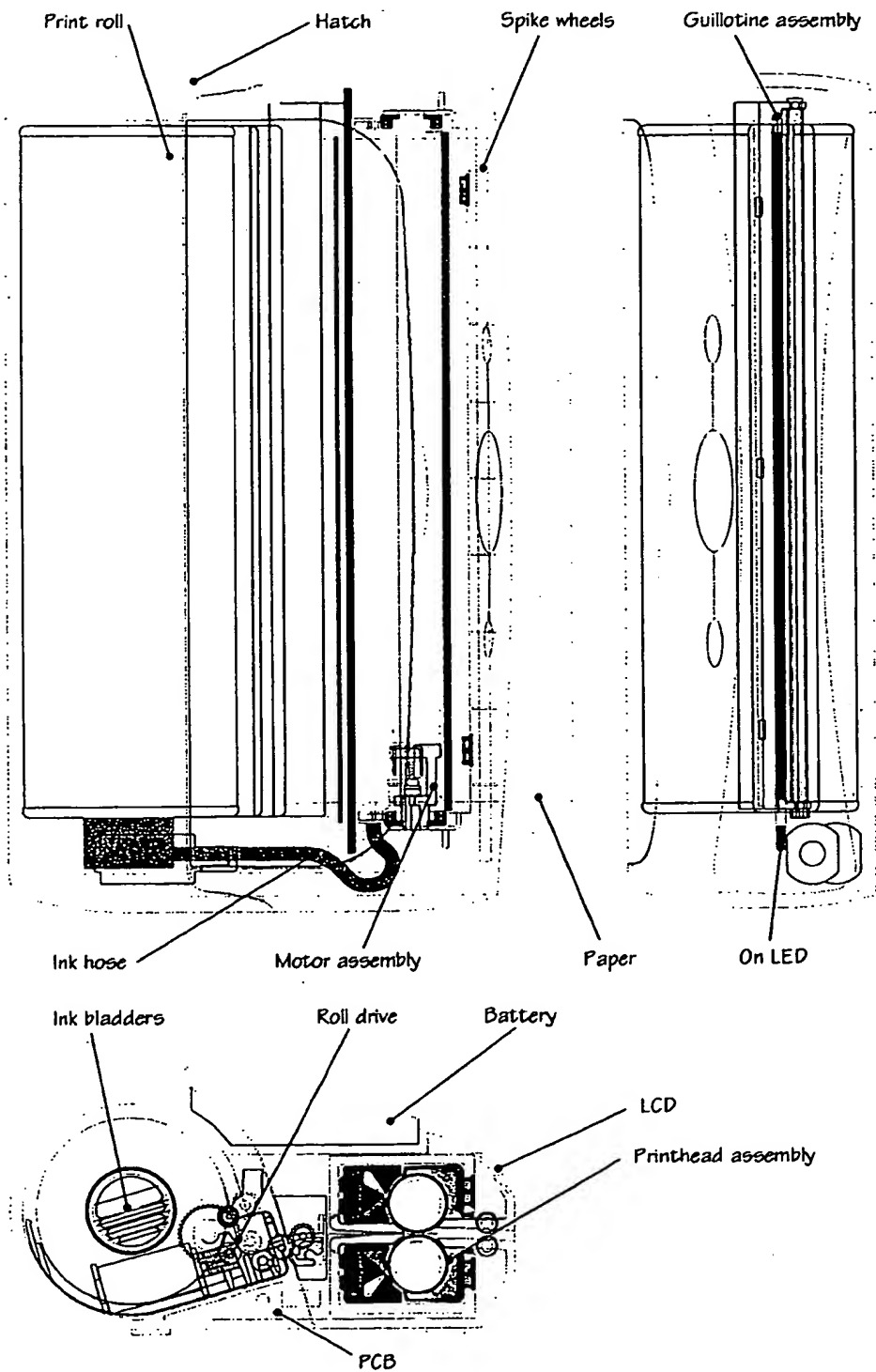Figure 25. Travelprinter R detail, showing duplexed imaging units and print cartridge

Print roll   Hatch   Spike wheels   Guillotine assembly

Ink hose   Motor assembly   Paper   On LED

Ink bladders   Roll drive   Battery

LCD

Printhead assembly

PCB

Figure 26. Travelprinter plan and elevations

11.8   MICROPRINTER

The Microprinter is a small, versatile, pocket-size printer/camera (see Figures 27 and 28). It has built-in mobile network communication hardware and software, allowing it to link to the Netpage Network and fetch documents from anywhere. In addition, the product is ergonomically configured and styled as a fully functional digital camera with the standard Classic, HDTV and Panoramic print formats for photography.

The Microprinter accommodates a 4" (100mm) page-width print cartridge with C, M, Y and infrared ink plus 5.4 meters of paper. This means the user can single-sided print 41 Netpages, 36 Classic, 30 Horizontal or 18 Panoramic prints or any combination thereof.
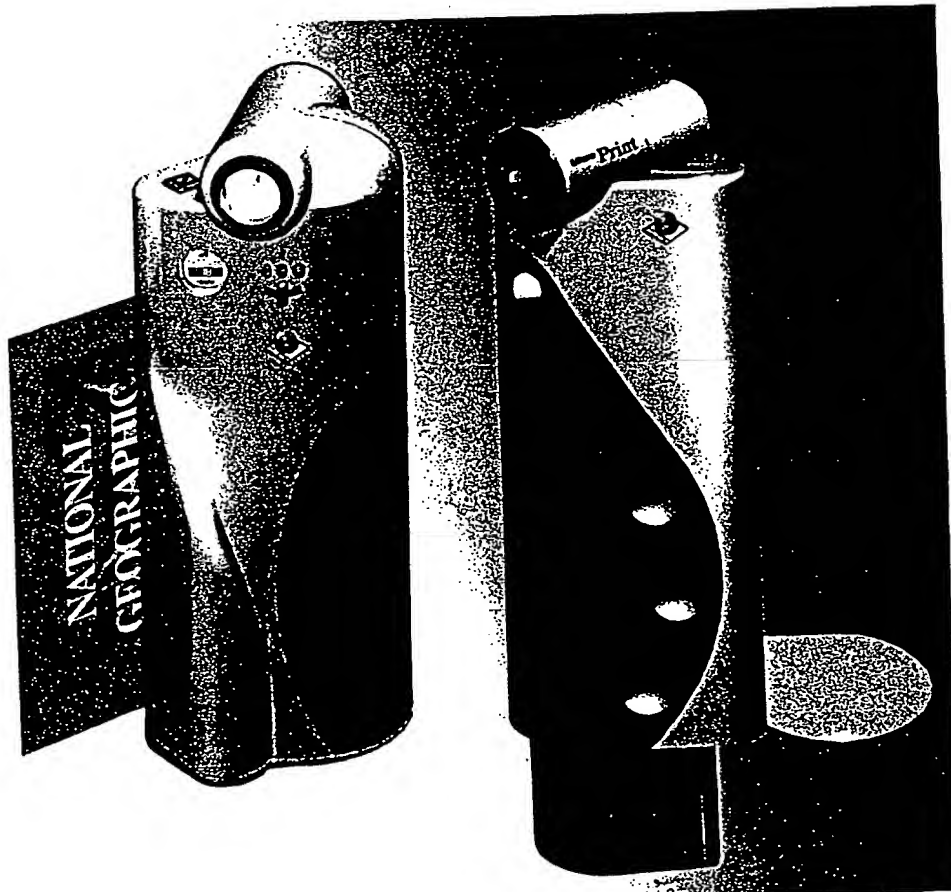
Figure 27. Microprinter rear view with printing in progress (left), and front view with print cartridge extracted (right)

The Microprinter is a fixed-lens camera with auto focus and digital photo enhancement capabilities, which allows the user to take sophisticated photos very simply and easily. A print button allows the user to print and reprint a photo or Netpage.

The Microprinter consists of two main front and rear moldings and a hatch. The main moldings accommodate the lens assembly, viewfinder optics and a rigid PCB. A flex PCB runs from the main board to the imaging chip, an LCD, the printhead assembly, the print-

head capping mechanism, a cutter assembly, the roll motor drive, various control switches and a CR2 battery.

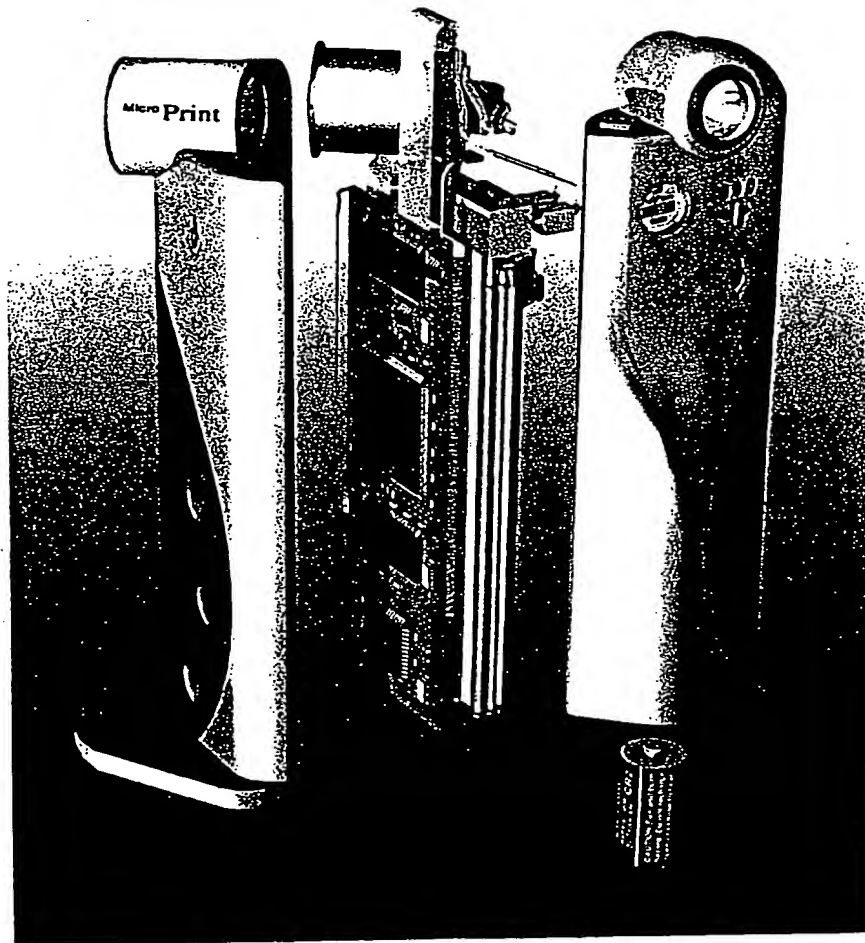The Microprinter is fully customizable in finishes and color.

Figure 28. Microprinter exploded view

11.9   NETPAGE PEN

The Netpage Pen is an intelligent, interactive writing implement that communicates with the Netpage Printers and the Netpage Network. It allows the user to write normally with an ink nib or use a non-marking stylus. Rotating the top of the pen selects between them.

The pen has a distinctive shape that is both ergonomic and functional, with imaging optics and electronics housed in the 'underbelly' (see Figures 29, 30 and 31).
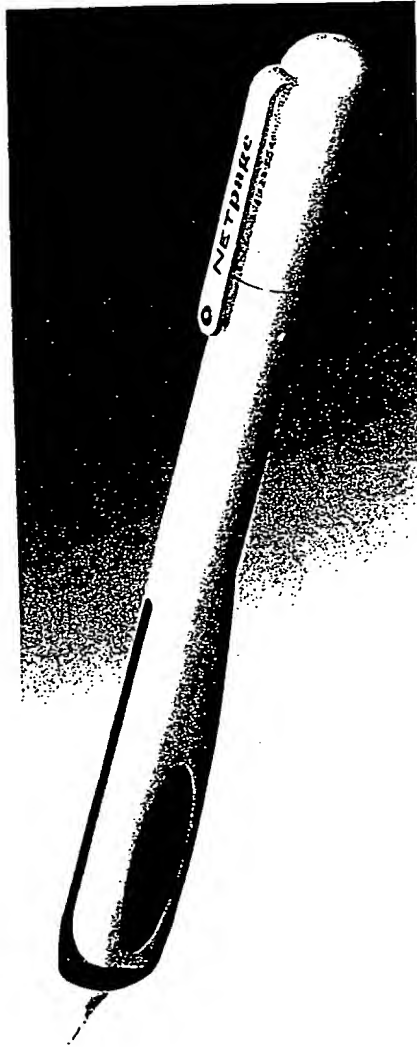
Figure 29. Netpage Pen, shown full size

The pen consists of a metal nib that is removable to allow ink cartridge replacement, followed by a tinted diffuser. The diffuser houses an antenna and two LEDs on a flex PCB; the first is located on top of the pen for good all-round visibility. It is a tri-color LED that responds in three modes when the pen is in use: periodic flashing green when it is online to the printer, momentary green when an operation succeeds, momentary red when an error occurs, yellow when it passes over an active area on the page. A separate lens is

mounted into the diffuser, which is optically de-coupled. The lens sits under a second LED that emits infrared light onto the page. The illuminated image is auto-focused onto a controller chip with an on-board image sensor via dedicated optics. The optics chassis accommodates a PCB with various components, including an induction coil for recharging and a MEMS chip. This chip also includes an optical sensor for detecting pressure movement in the metal cam turning when either the stylus or the ink cartridge is used for writing. The cam turning is connected to a terminal collar that has the contact strips for a rechargeable battery. This assembly is fitted into the pen top and connected via two flying leads to the PCB for power transmission. The top assembly is pushed into the body molding where it is free to rotate. By turning the top through 90-degree steps the pen has the stylus out, the pen out or both retracted. The pen has a standard length of 154mm and diameter of 11mm.
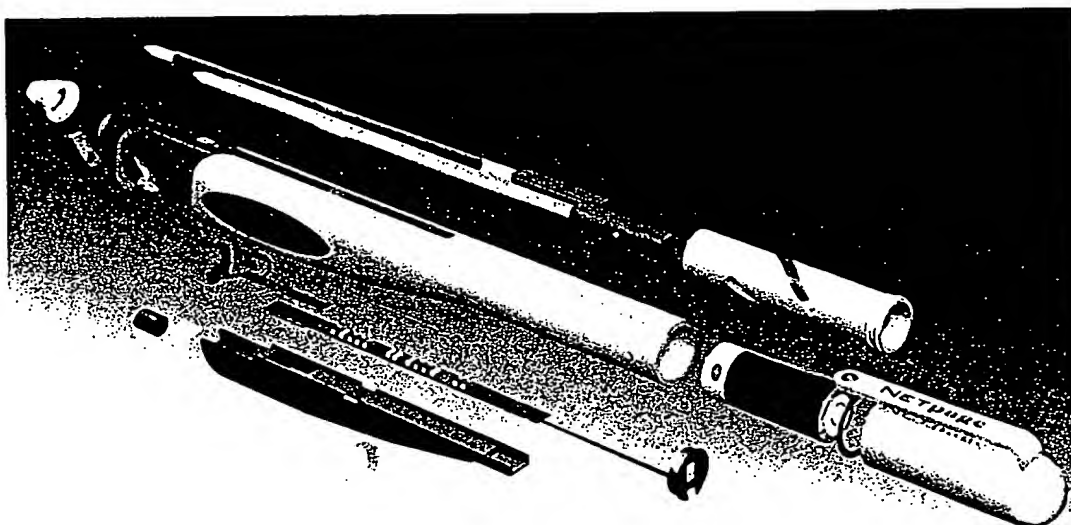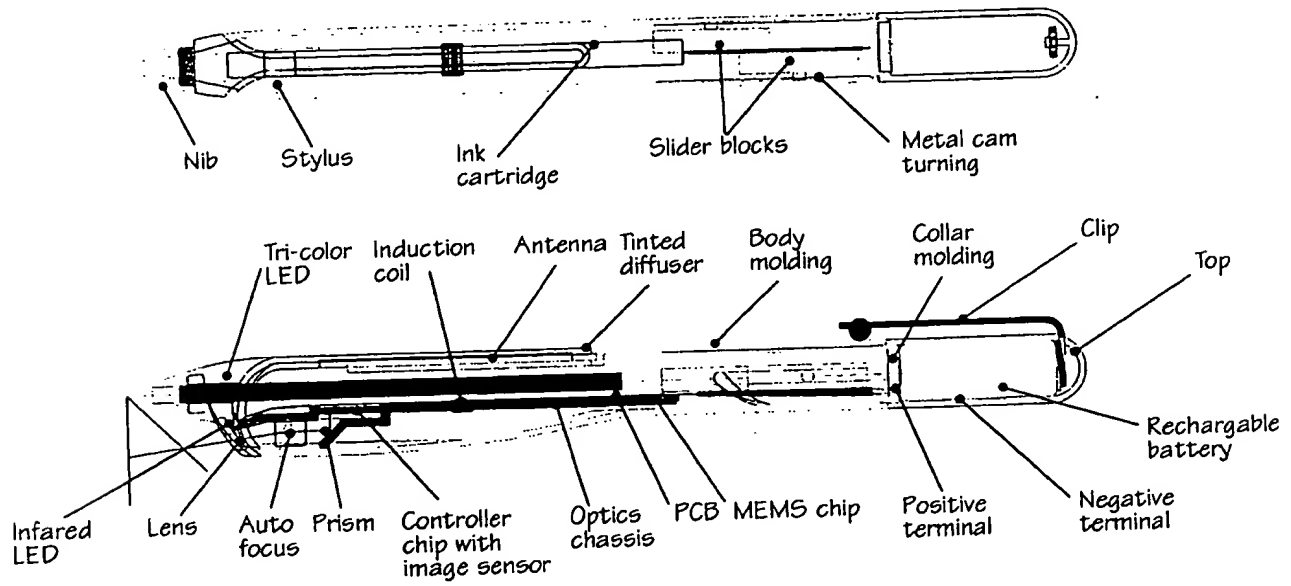

Figure 30. Netpage Pen, exploded view

Figure 31. Netpage Pen

11.10 PEN CHARGING CUP

The pen charging cup is a simple device that simultaneously recharges any number of Netpage Pens that are placed in it (see Figure 32). Figure 33 shows the unit components which are an inner molding, base molding, an induction coil, a termination block, a LED, a diffuser molding and an exit wire to a 3V AC power transformer. The inner molding accommodates the induction coil, which is held captive when the unit is assembled. The coil passes through a termination block, where flying leads to a LED and series current-limiting resistors is also attached. The LED is positioned at the top of the unit under a diffuser, so it acts as a beacon to indicate that the charging cup is active. The charging cup is 70mm in diameter by 93mm high.
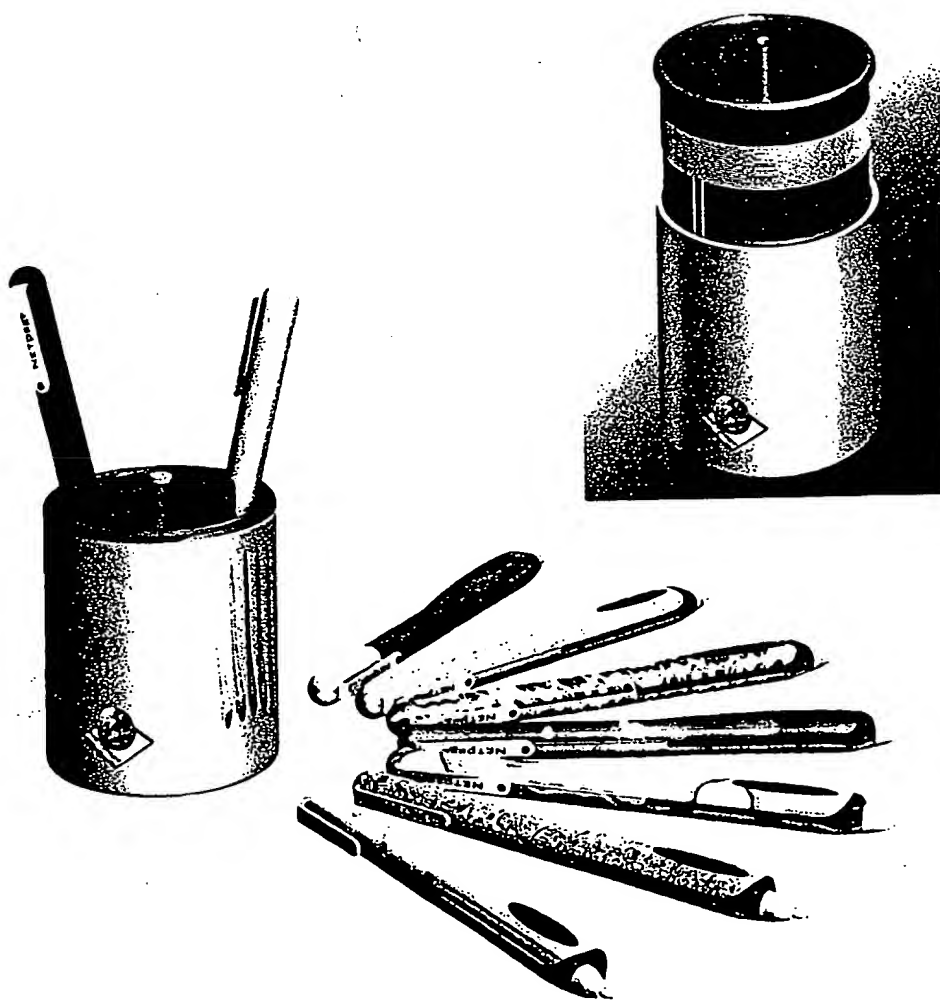
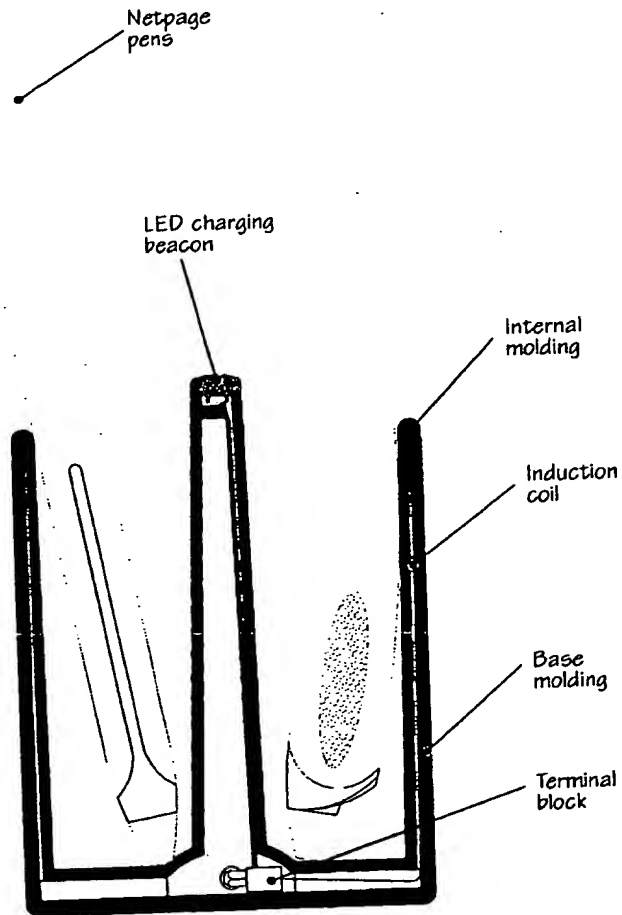**Figure 32. Pen charging cup and range of pens, and exploded view (inset)**

Netpage
pens

LED charging
beacon

Internal
molding

Induction
coil

Base
molding

Terminal
block

Figure 33. Netpage Pen charging cup

12 Memjet-Based Printing

A Memjet printhead produces 1600 dpi bi-level CMYK. On low-diffusion paper, each ejected drop forms an almost perfectly circular 22.5μm diameter dot. Dots are easily produced in isolation, allowing dispersed-dot dithering to be exploited to its fullest. Since the Memjet printhead is the width of the page and operates with a constant paper velocity, the four color planes are printed in perfect registration, allowing ideal dot-on-dot printing. Since there is consequently no spatial interaction between color planes, the same dither matrix is used for each color plane. Dot-on-dot printing minimizes 'muddying' of mid-tones caused by inter-color bleed.

A page layout may contain a mixture of images, graphics and text. Continuous-tone (con-tone) images and graphics are reproduced using a stochastic dispersed-dot dither. Unlike a clustered-dot (or amplitude-modulated) dither, a *dispersed-dot* (or frequency-modulated) dither reproduces high spatial frequencies (i.e. image detail) almost to the limits of the dot resolution, while simultaneously reproducing lower spatial frequencies to their full color depth, when spatially integrated by the eye. A *stochastic* dither matrix is carefully designed to be free of objectionable low-frequency patterns when tiled across the image. As such its size typically exceeds the minimum size required to support a particular number of intensity levels (e.g. 16×16×8 bits for 257 intensity levels).

Human contrast sensitivity peaks at a spatial frequency of about 3 cycles per degree of visual field and then falls off logarithmically, decreasing by a factor of 100 beyond about 40 cycles per degree and becoming immeasurable beyond 60 cycles per degree [31,40]. At a normal viewing distance of 12 inches (about 300mm), this translates roughly to 200-300 cycles per inch (cpi) on the printed page, or 400-600 samples per inch according to Nyquist's theorem.

In practice, contone resolution above about 300 ppi is of limited utility outside special applications such as medical imaging. Offset printing of magazines, for example, uses contone resolutions in the range 150 to 300 ppi. Higher resolutions contribute slightly to color error through the dither.

Black text and graphics are reproduced directly using bi-level black dots, and are therefore not antialiased (i.e. low-pass filtered) before being printed. Text is therefore *supersampled* beyond the perceptual limits discussed above, to produce smoother edges when spatially integrated by the eye. Text resolution up to about 1200 dpi continues to contribute to perceived text sharpness (assuming low-diffusion paper, of course).

The Netpage Printer uses a contone resolution of 267 ppi (i.e. 1600 dpi / 6), and a black text and graphics resolution of 800 dpi.

13 Document Data Flow

Because of the page-width nature of the Memjet printhead, each page must be printed at a constant speed to avoid creating visible artifacts. This means that the printing speed can't be varied to match the input data rate. Document rasterization and document printing are therefore decoupled to ensure the printhead has a constant supply of data. A page is never printed until it is fully rasterized. This is achieved by storing a compressed version of each rasterized page image in memory.

This decoupling also allows the RIP to run ahead of the printer when rasterizing simple pages, buying time to rasterize more complex pages.

Because contone color images are reproduced by stochastic dithering, but black text and line graphics are reproduced directly using dots, the compressed page image format contains a separate foreground bi-level black layer and background contone color layer. The black layer is composited over the contone layer after the contone layer is dithered.

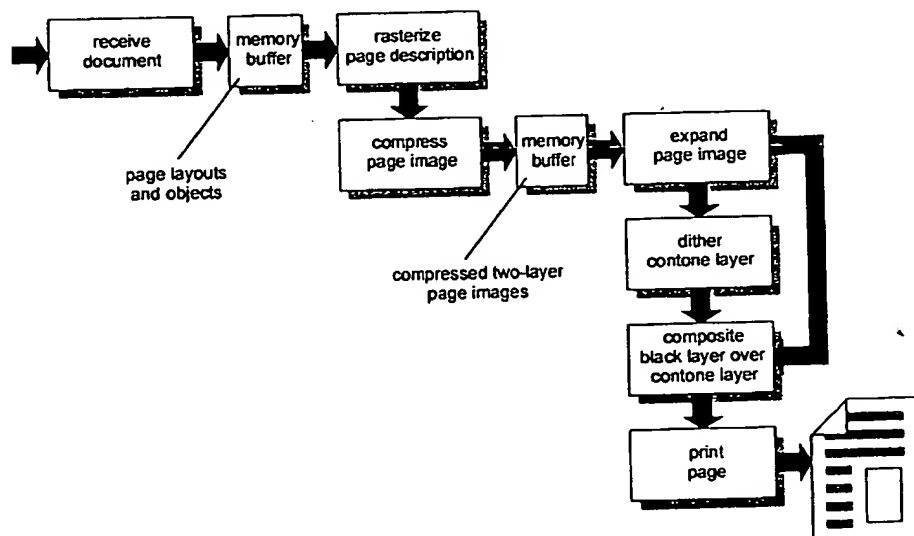Figure 34 shows the flow of a Netpage Printer document from network to printed page.

Figure 34. Netpage Printer document data flow

At 267 ppi, a Letter page of contone RGB or CMY data has a size of 19MB. Using lossy contone compression algorithms such as JPEG [45], contone images compress with a ratio up to 10:1 without noticeable loss of quality, giving a compressed page size of 1.9MB.

At 800 dpi, a Letter page of bi-level data has a size of 7MB. Coherent data such as text compresses very well. Using lossless bi-level compression algorithms such as Group 4 Facsimile [7], ten-point text compresses with a ratio of about 10:1 (as discussed in Section 18.2.1.2), giving a compressed page size of 0.8MB.

Once dithered, a page of CMY contone image data consists of 86MB of bi-level data. Using lossless bi-level compression algorithms on this data is pointless precisely because the optimal dither is stochastic - i.e. since it introduces hard-to-compress disorder.

The two-layer compressed page image format therefore exploits the relative strengths of lossy JPEG contone image compression and lossless bi-level text compression. The format is compact enough to be storage-efficient, and simple enough to allow straightforward real-time expansion during printing.

Since text and images normally don't overlap, the normal worst-case page image size is 1.9MB (i.e. image only), while the normal best-case page image size is 0.8MB (i.e. text only). The absolute worst-case page image size is 2.7MB (i.e. text over image). Assuming a quarter of an average page contains images, the average page image size is 1.1MB.

14 Printer Controller Architecture

The Netpage Printer controller consists of a controlling processor, a factory-selected network interface, a radio transceiver, dual raster image processor (RIP) DSPs, duplexed print engines, flash memory, and 64MB of DRAM, as illustrated in Figure 35.
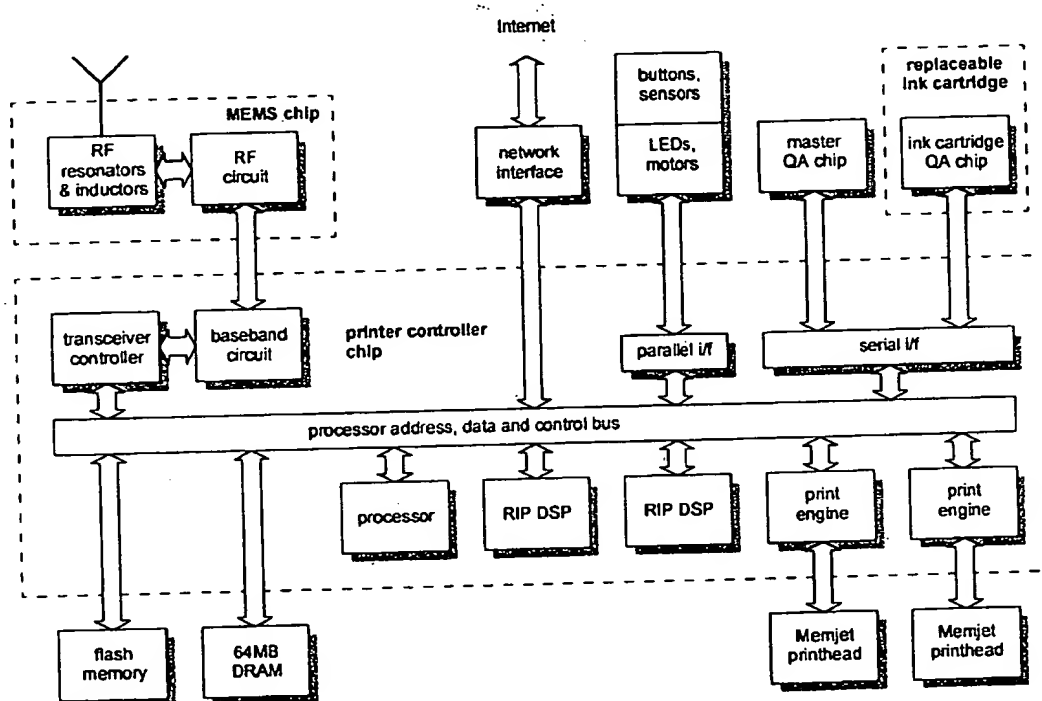

Figure 35. Basic printer controller architecture

The controlling processor handles communication with the Internet and with local wireless pens, controls the user interface (buttons and LEDs), controls the paper transport, handles ink cartridge authentication and ink monitoring, and feeds and synchronizes the RIP DSPs and print engines. It consists of a medium-performance general-purpose microprocessor.

The RIP DSPs rasterize and compress page descriptions to the Netpage Printer's compressed page format. Each print engine expands, dithers and prints page images to its associated Memjet printhead in real time (i.e. at 30 or 45 pages per minute). The duplexed print engines print both sides of the page simultaneously.

The printer controller's flash memory holds the software for both the processor and the DSPs, as well as configuration data. This is copied to main memory at boot time.

The processor, DSPs, print engines and digital transceiver components are integrated in a single ASIC. The MEMS and analog RF components are integrated in a separate MEMS chip, which is also used in the wireless pen. Additional pen-specific components in the

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The law says: (1) that you have a right to be represented by a lawyer or anyone who does not work for the District of Columbia; (2) that you can bring witnesses for your side; (3) that the Agency will pay for reasonable expenses for the hearing, like having an interpreter or transportation costs for you and your witnesses; and (4) that free legal services are available to you. If you continue to get Food Stamps and/or TANF benefits after requesting a hearing, you must repay the full amount of the benefits you received during this hearing if the hearing decision is against you. If you are not eligible for financial, medical, or food assistance at this time, you may reapply if things change.

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